UIC PERMIT APPLICATION

Wexford Water Technologies, LLC
Well No. 1
Class I Non-Hazardous Deepwell

Wexford County Landfill
Wexford County
T23N R9W Section 34
Well No. 1
EPA Permit # TBD

August 5, 2015
Revised March 2017

Prepared By:

Petrotek Engineering Corporation
5935 South Zang Street
Suite 200
Littleton, Colorado 80127
Phone: (303) 290-9414
Fax: (303) 290-9580

1.0 PERMIT APPLICATION AND INTRODUCTION

Through the submittal of this application, Wexford Water Technologies, LLC (WWT) requests authorization from the US Environmental Protection Agency (EPA) to permit a non-hazardous Class I disposal well and operate it pursuant to the applicable Underground Injection Control (UIC) regulations. The well is to be authorized by EPA with an appropriate UIC permit number (MI-4-TBD) and is to be located in Wexford County, northeast of Cadillac, Michigan and south of Manton, Michigan. The well will be installed 77 feet from the west line and 2,439 feet from the north line of Section 34, T23N R9W. A map identifying the well location is included as Figure 1. A completed copy of US EPA UIC Form 4 and required attachments to this form are included in this document.

Fresh water aquifers in the vicinity of this well will be protected by strings of casing and cement. The waste fluids will be delivered to the disposal formations (expected to be the Traverse and Dundee, but may extend to the Amherstburg, Bois Blanc, Sylvania and/or Bass Islands if necessary) under positive pressure flow through 2 7/8" or 3-1/2" diameter lined or coated steel tubing and a coated tension set packer. The well will have one long string protective casing extending into the injection interval with cement circulated to the surface. The annulus area between the protective casing and injection tubing will be filled with inhibited fresh water. The annulus pressure will be continually monitored to detect any leaks in the tubing or casing and maintained at a pressure of more than 100 psi above the tubing pressure.

Relevant administrative data regarding the permit are summarized as follows:

Applicant:	Wexford Water Technologies, LLC
State:	Michigan
County:	Wexford
Facility Address:	990 N U.S. Hwy 131, Manton, MI 49663
Mailing Address:	P.O. Box 1030, 3947 U.S. 131 North Kalkaska, MI 49646
Location of Well:	T23N R9W Section 34
USEPA ID Nos.:	MI-165-1I-0002, TBD
Michigan ID No.:	TBD
Contact:	Mr. Edward G. Ascione Ascione, President; 231-258-7300

The Wexford Water Technologies (WWT) Well No. 1 non-hazardous waste disposal well is a new well that will be installed to dispose of non-hazardous landfill leachate. The well will be completed for injection into the Dundee and/or Traverse Formation, although the deeper Amherstburg, Sylvania, Bois Blanc, and/or Bass Island may be used if the shallower Dundee and Traverse do not offer sufficient disposal capacity. Well No. 1 will also be permitted under Part 625 of the MDNR Mineral Well Act with a State Permit number to be determined.

Non-hazardous fluid generated on-site from the primary and secondary leachate collection system at the landfill will be disposed in Well No. 1. If needed, associated local groundwater derived from the landfill site and fluids derived from or necessary for the maintenance and repair of the well may also be injected. Fluids will be transferred by pipe from the collection system units to storage tanks where the leachate will be comingled prior to injection.

OMB No. 2040-0042 Approval Expires 11/30/2014

EPA	United States Environmental Protection Agency **Underground Injection Control** **Permit Application** *(Collected under the authority of the Safe Drinking Water Act. Sections 1421, 1422, 40 CFR 144)*	I. EPA ID Number	T/A	C
		U		

Read Attached Instructions Before Starting

For Official Use Only

Application approved (mo day year)	Date received (mo day year)	Permit Number	Well ID	FINDS Number
		MI-165-1I-0002	WWT Well No. 1	

II. Owner Name and Address			III. Operator Name and Address		
Owner Name Wexford Water Technologies, LLC			Owner Name Wexford Water Technologies, LLC		
Street Address PO Box 1030, 3947 US 131 North		Phone Number (231) 258-7300	Street Address PO Box 1030, 3947 US 131 North		Phone Number (231) 258-7300
City Kalkaska	State MI	ZIP CODE 49646	City Kalkaska	State MI	ZIP CODE 49646

IV. Commercial Facility	V. Ownership	VI. Legal Contact	VII. SIC Codes
☐ Yes ☒ No	☒ Private ☐ Federal ☐ Other	☒ Owner ☐ Operator	4953

VIII. Well Status *(Mark "x")*

☐ A. Operating	Date Started (mo day year)	☐ B. Modification/Conversion	☒ C. Proposed

IX. Type of Permit Requested *(Mark "x" and specify if required)*

☒ A. Individual ☐ B. Area	Number of Existing Wells	Number of Proposed Wells	Name(s) of field(s) or project(s)
	0	1	

X. Class and Type of Well *(see reverse)*

A. Class(es) (enter code(s))	B. Type(s) (enter code(s))	C. If class is "other" or type is code 'x,' explain	D. Number of wells per type (if area permit)
1	1	N/A	N/A

XI. Location of Well(s) or Approximate Center of Field or Project | **XII. Indian Lands (Mark 'x')**

Latitude Deg	Latitude Min	Latitude Sec	Longitude Deg	Longitude Min	Longitude Sec	Township and Range Sec	Twp	Range	1/4 Sec	Feet From	Line	Feet From	Line
44	20	49.3	-85	23	49.9	34	23N	9W	NW	2,439	N	77	W

XII. Indian Lands: ☐ Yes ☒ No

XIII. Attachments

(Complete the following questions on a separate sheet(s) and number accordingly; see instructions)

For Classes I, II, III, (and other classes) complete and submit on a separate sheet(s) Attachments A--U (pp 2-6) as appropriate. Attach maps where required. List attachments by letter which are applicable and are included with your application.

XIV. Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

A. Name and Title *(Type or Print)*	B. Phone No. *(Area Code and No.)*
Edward G. Ascione, President	(231) 258-7300
C. Signature	D. Date Signed
[signature]	3-29-17

EPA Form 7520-6 (Rev. 12-11)

2.0 US EPA FORM 7520-6 PERMIT APPLICATION ATTACHMENTS

2.A AREA OF REVIEW METHODS

Give the methods and, if appropriate, the calculations used to determine the size of the area of review (fixed radius or equation). The area of review shall be a fixed radius of 1/4 mile from the well bore unless the use of an equation is approved in advance by the Director.

Response:

The radius of investigation used in this permit request has been based on standard practices applied historically in Region 5. Under Section 146.6 of the UIC regulations (40CFR), the area of review (AOR) for a non-hazardous Class I injection well is defined as either the calculated zone of endangering influence or a fixed radius of not less than one-fourth mile. USEPA Region 5 has required a fixed two-mile radius AOR for the evaluation of all non-fresh water penetrations in the vicinity of a Class I non-hazardous well in Michigan.

Therefore, a fixed radius of two (2) miles for evaluation of non-fresh water artificial penetrations as specified by the USEPA Region 5 has been investigated for Class I injection into the proposed WWT well. As discussed in this section, this distance is substantially greater than the probable cone-of-influence (COI) for operation of the proposed well as a Class I injector. A fixed radius of one-mile from the property boundary, which significantly exceeds the required one-quarter (1/4) mile radius from the proposed well location, has been used to evaluate shallow fresh-water artificial penetrations. Area of review radii for the freshwater penetrations has been applied from the property boundaries for the well facility.

Although water well investigation requirements have been waived by the USEPA Region 5 in past submittals, fresh water well data for penetrations located within the area have been identified from state files and submitted. In addition, an updated map generated from Michigan Department of Environmental Quality (MDEQ) data has been submitted to summarize these data.

While the USEPA Region 5 fixed two-mile radius AOR has been adopted, the following critical pressure rise and COI calculations are presented to define pressure conditions within the AOR assuming a WWT Traverse injection well. These data show that the calculated pressure rise at the only well in the AOR, the George Wilcox No. 1 (Well Permit No. 12415, Figure B-1), is much smaller than the 191 psi necessary to cause upward movement of formation brine to a USDW at the George Wilcox No. 1 location.

Critical Pressure Rise

To calculate the COI, a value must first be assigned for the pressure increase in the injection interval that would be sufficient to cause injection zone brine to rise in an open pathway to the base of the lowermost USDW. This critical pressure rise, Pc, is assigned as indicated in Figure A-1.

The pressure required at the top of the injection interval to support injection zone brine in the configuration indicated is, in psi units:

$$P = 0.433\ [y_B D_B + y_w(D_w - L)]$$

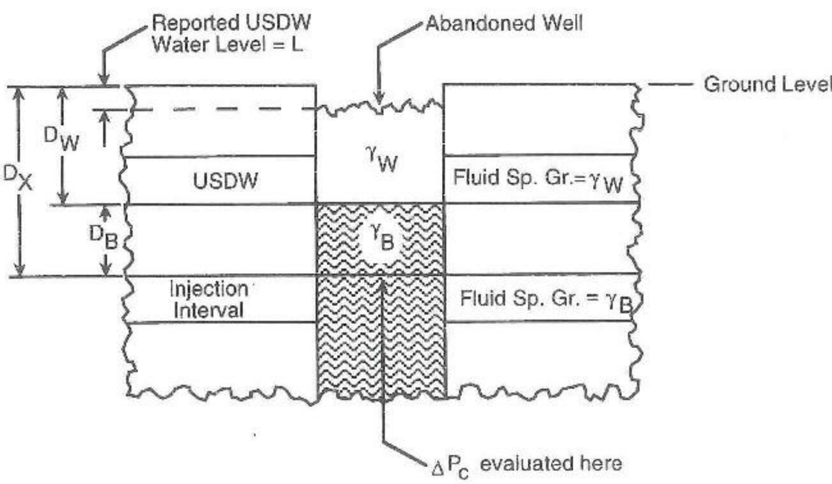
where: $D_B = D_x - D_w$

and the pressure rise is then:

$$Pc = 0.433\ [y_B D_B + y_w(D_w - L)] - Po$$

where Po is the original, pre-injection value for pressure at the top of the injection interval expressed in psi units.

FIGURE A-1 CRITICAL PRESSURE RISE



Original pressure in the Dundee has been estimated based on work by Vugrinovich (1986), who identified typical pressure gradients found in the area for this formation. For the estimated top of the injection interval of 3,166 feet, a very conservative gradient of 0.426 psi/ft yields a pressure of 1,349 psi at the top of the proposed Traverse completion.

In assigning the critical pressure rise and calculating the cone-of-influence at this site, the base of the lowermost USDW is assigned as 890 feet, as discussed in Section 2.3 of this document. The lowest potentiometric surface of the water table within 2 miles of the well is projected to be closer than 25 feet from ground level since some local water production wells are less than 50 feet deep.

TABLE A-1 CRITICAL PRESSURE CALCULATION PARAMETERS

Parameter	Value
Original pressure, Po	1349 psi @ 3166 feet
Depth to base of USDW, D_w	890 feet
Depth to top of injection zone, D_x	3166 feet
Depth to USDW fluid level, L	25 feet
Density of USDW fluids, y_w	1.0
Density of injectate or injection zone brine, y_B	1.183

These values were used in the above equation to compute the critical pressure rise as follows:

$$Pc = 0.433\ [1.183(3166\text{-}890) + 1.0(890\text{-}25)] - 1349\ \text{psi}$$

or:

$$Pc = 191\ \text{psi}$$

As a further sensitivity, a critical pressure was calculated assuming that the cemented casing and borehole are full of mud from the surficial aquifer saturated level to the top of the Traverse completion as follows:

$$Pc = 0.433\ [1.08(3166\text{-}25)] - 1349\ \text{psi}$$

or:

$$Pc = 120\ \text{psi}$$

Cone-of-Influence

Based on the calculated values for the critical pressure rise, the cone-of-influence can be calculated for the well over a twenty-year period of injection. At the proposed well, there is projected to be a limited cone-of-influence for continuous injection at a rate of 57 gpm (1,954.3 bwpd). This value can be confirmed by examination of the following calculation (oilfield units) of pressure rise in the reservoir:

$$dP = \ -70.6\ qB\mu\ /kh\ *\ \ln\ (\ [\ 1{,}688\ \Phi\mu c_t r^2\ /kt\ ]\ )$$

where the values listed in Table A-2 have been assigned based on site-specific information. It is noted that this calculation method and input values yields a differential pressure due to injection that is larger than a differential pressure drawdown that has been observed. A local abandoned Traverse well (Solon-Webb No. 1 PN 25348) historically produced brine fluid at a rate of 38.5 gpm with a drawdown of approximately 303 psi at the wellbore, so the pressure rise calculated for this COI at over a mile from the borehole is conservative.

$$dP = -70.6*1954.3*(1.01)*0.85 / (15*348) * \ln ([1,688*0.1*0.85*6.2x10^{-6} *5,650^2 /(15)(175320)])$$

$$dP = = 102.8 \text{ psi}$$

It is noted that the "ln" approximation is not rigorous but the Ei solution to this equation yields a very similar value of 98.7 psi. The above calculation for pressure rise due to twenty years of injection at a rate of 57 gpm yields a conservative pressure increase of approximately 98.5 psi at the nearest well location (5,650 feet, George Wilcox No. 1, No. 12415). This value is much smaller than the conservatively calculated critical pressure, Pc, of 191 psi which would be necessary before there is potential for upward movement of formation brine to the base of a USDW if an open pathway were present at this location. This pressure (191 psi) is estimated to exist at a distance of less than 808 feet from the injector. Further, the value is also smaller than the 120 psi that would be required to displace mud in the abandoned wellbore, neglecting gel strength, which is conservatively estimated to be possible at distances of less than 3,865 feet from the proposed injector. Therefore the cone-of-influence at this site does not intersect the nearest offset wellbore, even under the most conservative scenarios. Figure A-2 presents a summary of the pressure distribution in the reservoir compared to the two conservatively calculated critical pressure rise values. Due to the higher permeability (>>15 md) and the relatively lower original pressure (gradient < 0.425 psi/ft) likely to be encountered in the Traverse/ Dundee Limestone injection formation at this site, there exists no potential for contamination of USDW resources due to the well within the statutory minimum 2-mile radius area of review and the offset George Wilcox No. 1 well meets the non-endangerment standards currently plugged.

TABLE A-2 CONE-OF-INFLUENCE PARAMETERS

Parameter	Calculation	Value
Flow rate, q	57 gpm *1440 min/day* bbl/42 gal	1954.3 bbl/d
Thickness, h	Assigned value	348 feet
Formation Volume Factor, B	Assigned value	1.01
Porosity, Φ	Assigned value	0.10
Permeability, k	Assigned value	15 millidarcies
Viscosity, μ	Assigned value	0.85 centipoise @ 106 degrees F
Total Compressibility, C_t	$3.2x10^{-6}$ psi^{-1} + $3x10^{-6}$ psi^{-1}	$6.2x10^{-6}$ psi^{-1}
Radius, r	assumed	5,650 feet
Time, t	20 years x 365.25 days/yr * 24hr/day	175,320 hours

References:

Vugrinovich, Raymond, 1986, Patterns of Regional Subsurface Fluid Movement in the Michigan Basin, Michigan Geological Survey Division Open File Report OFR 896-6.

2.B AREA OF REVIEW (AOR): MAPS OF WELLS IN AREA

Submit a topographic map, extending one mile beyond the property boundaries, showing the injection well(s) or project area for which a permit is sought and the applicable area of review. The map must show all intake and discharge structures and all hazardous waste, treatment, storage, or disposal facilities. If the application is for an area permit, the map should show the distribution manifold (if applicable) applying injection fluid to all wells in the area, including all system monitoring points. Within the area of review, the map must show the following:

Class I

The number, or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, mines (surface and subsurface), quarries, and other pertinent surface features, including residences and roads, and faults, if known or suspected. In addition, the map must identify those wells, springs, other surface water bodies, and drinking water wells located within one-quarter mile of the facility property boundary. Only information of public record is required to be included on this map.

Response:

Maps based on available public records have been prepared as summaries of the required data. Figure B-1 is a map showing the location of all deep producing wells, injection wells, abandoned wells, and dry holes within a two mile radius of the proposed WWT Disposal Well; this map is current as of July 31, 2016. Since data outside the AOR were used to characterize the site, additional wells are also identified outside this radius along with a scale showing a 5-mile distance. Figure B-2a is a map showing the location of all shallow and fresh-water water wells in a one mile area around the Wexford County Landfill, excluding monitoring wells associated with the landfill. Figure B-2b shows the location of monitoring wells in the Wexford County Landfill area. Figure B-3 is a topographic map showing the location of pertinent surface features, springs, and surface water bodies within 1 mile of the facility property boundary. Figure B-4 presents local property owners adjacent to and abutting the Wexford County Landfill property.

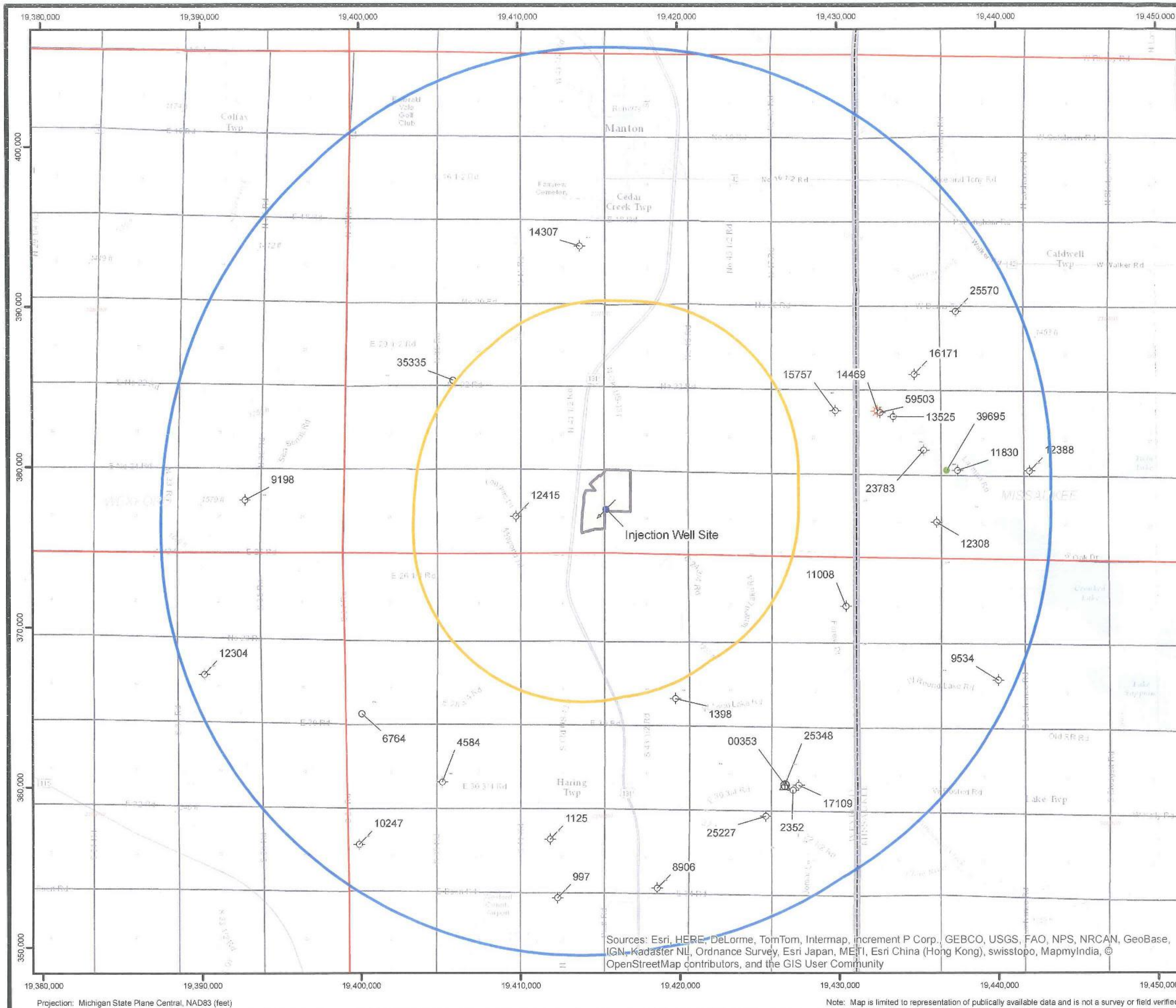
ARTIFICIAL PENETRATIONS

There is only one artificial penetration that reaches the depth of any proposed injection zones within the (2) two mile radius surrounding the WWT Landfill property site of the proposed disposal well. Data for this deep well is summarized in the following section (Tables C-1 and C-2) and copies of pertinent MDEQ records for this well are presented in Section 2.C. For completeness and to document site characterization efforts, MDEQ well file data for all wells within a five mile radius are also included in Section 2.C.

Figure B-1 is a map showing the location of all deep producing wells, injection wells, abandoned wells, and dry holes, within and outside the required area of review. The legend on this map contains pertinent information for all wells within the area of review, and beyond. Water well data found through consultation of older records within one mile of the property boundary are included at the end of Section 2.C and are shown in Figures B-2a (residential wells) and B-2b (monitoring and purge wells). There are a total of 60 known domestic water wells within a one mile radius of the disposal well property, and there are no water wells within the regulatorily mandated ¼ mile radius. The well count does not include the monitoring or purge wells associated with the landfill that are shown in Figure B-2b. Table C-3 presents information about the domestic water wells in the one mile area, and Table C-4 presents information about the monitoring wells. Of the 77 monitoring wells, twelve (12) are used by Wexford County Landfill, LLC to monitor landfill activities. The remaining are managed by the County of Wexford under a separate activity and are not part of the monitoring system associated with the landfill. Appendix C.1 at the end of Section 2.C (which is a CD-rom that includes well data) also presents the water well information that is publicly available for both domestic and monitoring wells.

TOPOGRAPHIC MAP AND PROPERTY OWNERSHIP

A topographic map extending several miles beyond the Wexford County Landfill site, showing the injection well and all hazardous waste treatment, storage or disposal facilities is included as Figure B-3. In addition, the map shows the location of all surface bodies of water and roads within a two mile radius. There are no known springs, mines, or quarries within the two-mile radius. Figure B-4 shows property owners adjacent to the Wexford County Landfill and Table B-1 presents information about these properties. It is noted that the mineral rights associated with the landfill property are controlled by the permit applicant.



Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- 2 Mile AOR
- 5 Mile radius

well_type

- Dry Hole
- Location
- Natural Gas Well
- Oil Well
- Other Well
- Part 625 Natural Brine
- Injection Well Site
- Wexford Property Boundary

Permit No	API Well No
9534	21113095340000
11830	21113118300000
12308	21113123080000
12388	21113123880000
13525	21113135250000
14469	21113144690000
16171	21113161710000
16171	21113161710100
23783	21113237830000
25570	21113255700000
25570	21113255700100
39695	21113396950000
59503	21113595030000
997	21165009970000
1125	21165011250000
1398	21165013980000
2352	21165023520000
4584	21165045840000
6764	21165067640000
8906	21165089060000
9198	21165091980000
10247	21165102470000
10661	21165106610000
11008	21165110080000
12304	21165123040000
12415	21165124150000
14307	21165143070000
15757	21165157570000
17109	21165171090000
17109	21165171090100
25227	21165252270000
25348	21165253480000
35335	21165353350000

0 1 2 Miles

Wexford Water Technologies, LLC

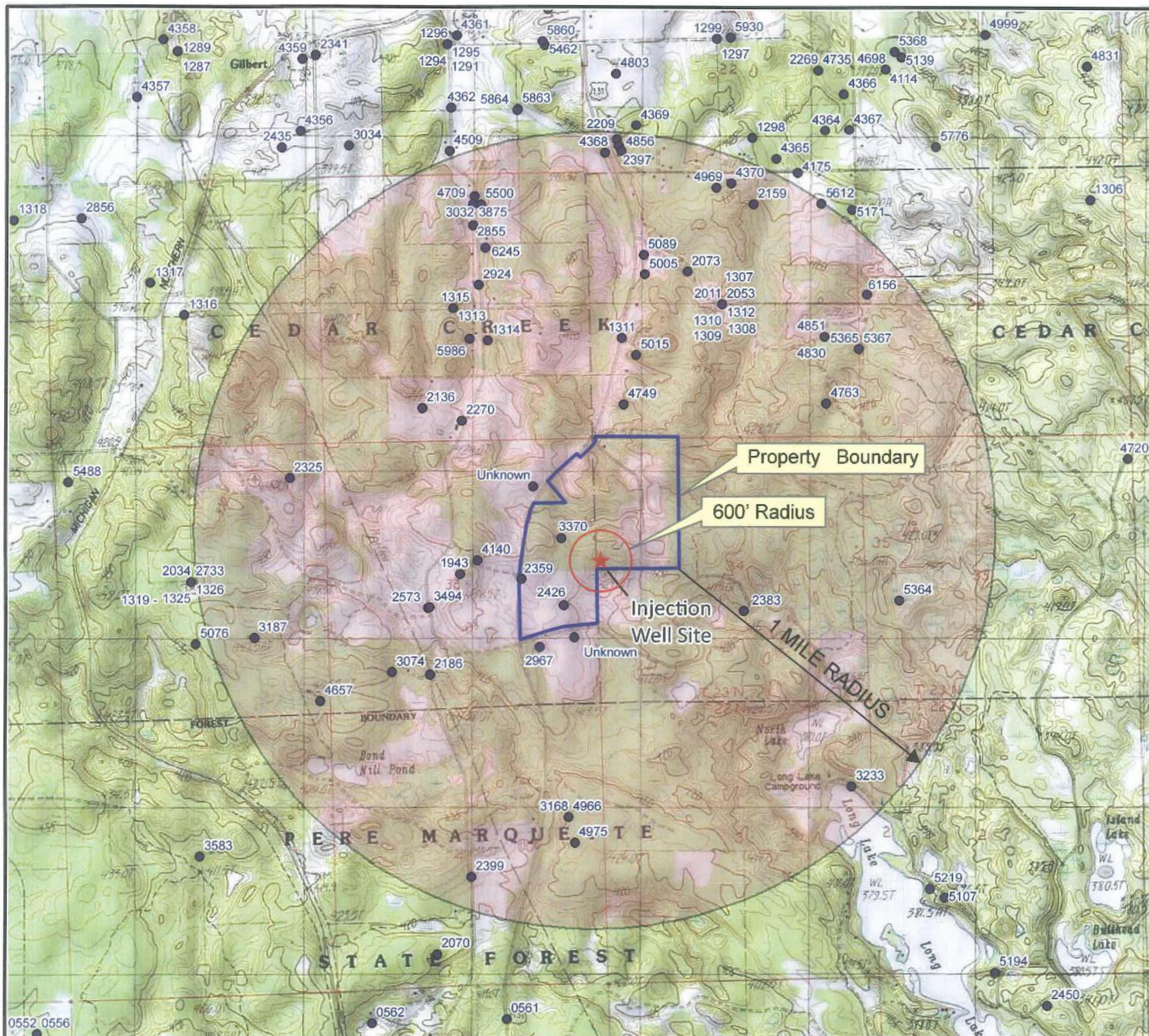
990 N US Highway 131, Manton, MI 49663

Figure B-1
Artificial Penetration Map

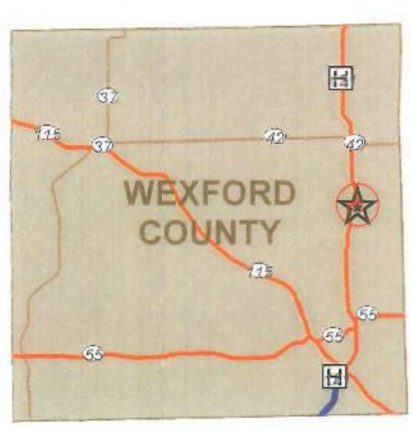
2015 Wexford Well No.1 Permit Application

Scale: 1:72,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_B-01.mxd	By: JLM Checked: CW

Petrotek



REFERENCE: Copyright: 2011 National Geographic Society, i- cubed



NOTES

1. WELLS ARE REFERENCED BY THE WELL ID. ONLY WELLS WITH A WELL ID ARE INCLUDED ON THIS MAP.
2. WELL IDs SHOWN ARE THE LAST 4 DIGITS OF THE ACTUAL WELL ID NUMBER.

3000 1500 0 3000 Feet

Golder Associates
Michigan

SCALE	AS SHOWN
DATE	3/14/12
DESIGN	CEP
GIS	DJC
CHECK	
REVIEW	
FILE No.	12388763C001- GIS
PROJECT No.	123- 88763 REV. 0

REGIONAL WATER WELL LOCATION MAP
WEXFORD COUNTY LANDFILL, LLC.
WEXFORD COUNTY, MICHIGAN

HYDROGEOLOGIC REPORT

FIGURE 3

H:\ 12x- Projects\ 123- 88763 - Wexford County Landfill\ figures\ c- Hydrogeologic Report \ 12388763C001- GIS.mxd

Modified From: Golder Associates, 2012

"Unknown" Labeled wells were identified by Golder, Assoc. 2012 but are not in the current MDEQ Waterwell database. These wells were retained for consistency with the previous map. Wells 2359, 3370, 2426 and 5986 were added to Golder, 2012 to show wells within the property boundary and a new well in the MDEQ database (5986).

Well 2383 is mislocated in the MDEQ database. The Lat.-Long. locates it in the middle of the new highway West of Wexford County Landfill. Based on the well address in "Bing Maps" it shows the Golder map location to be correct.

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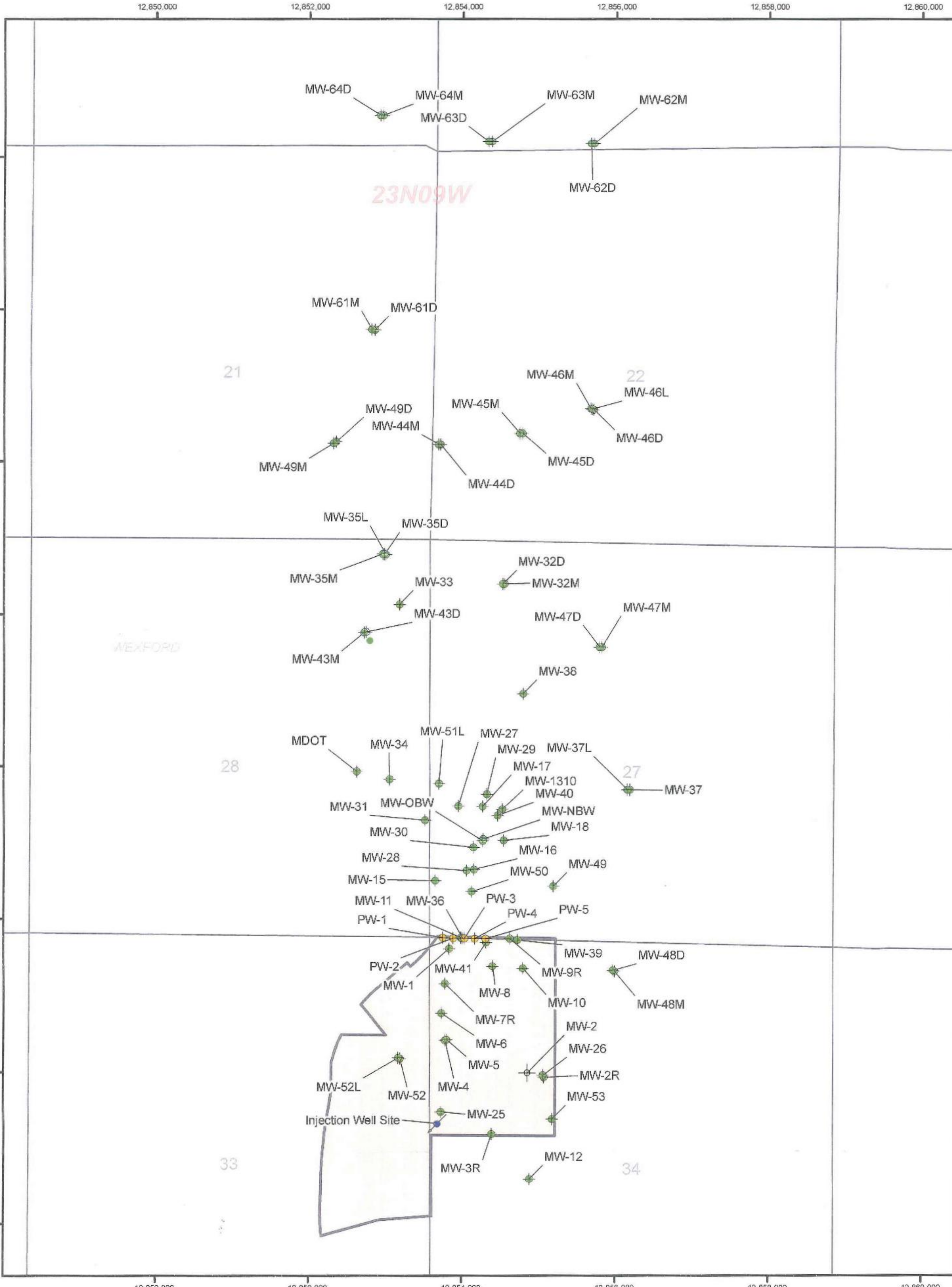
Figure B-2a
Shallow Water Well Map
2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 3/2017
WWTEPAPA_Fig_B-02a.ai	By: JLM Checked: CW

Petrotek
5935 South Zang Street, Suite 200 Littleton, Colorado 80127 USA 303-290-9414 www.petrotek.com



Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

Injection Well Site

Monitor Wells

Abandoned Well

Monitor Well

Purge Well

Wexford Property Boundary

Note: Map compiled from CTI and Asociates, Inc. RAP Area and Environmental Monitoring Well Locations, 2010 and from American Waste, LLC., Date unknown.

N

0 1,000 2,000 3,000 Feet

Wexford Water Technologies, LLC

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Figure B-2b
Monitoring Well Location Map

2015 Wexford Well No.1 Permit Application

Scale: 1:15,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_B-02b.mxd	By: JLM / Checked: CW

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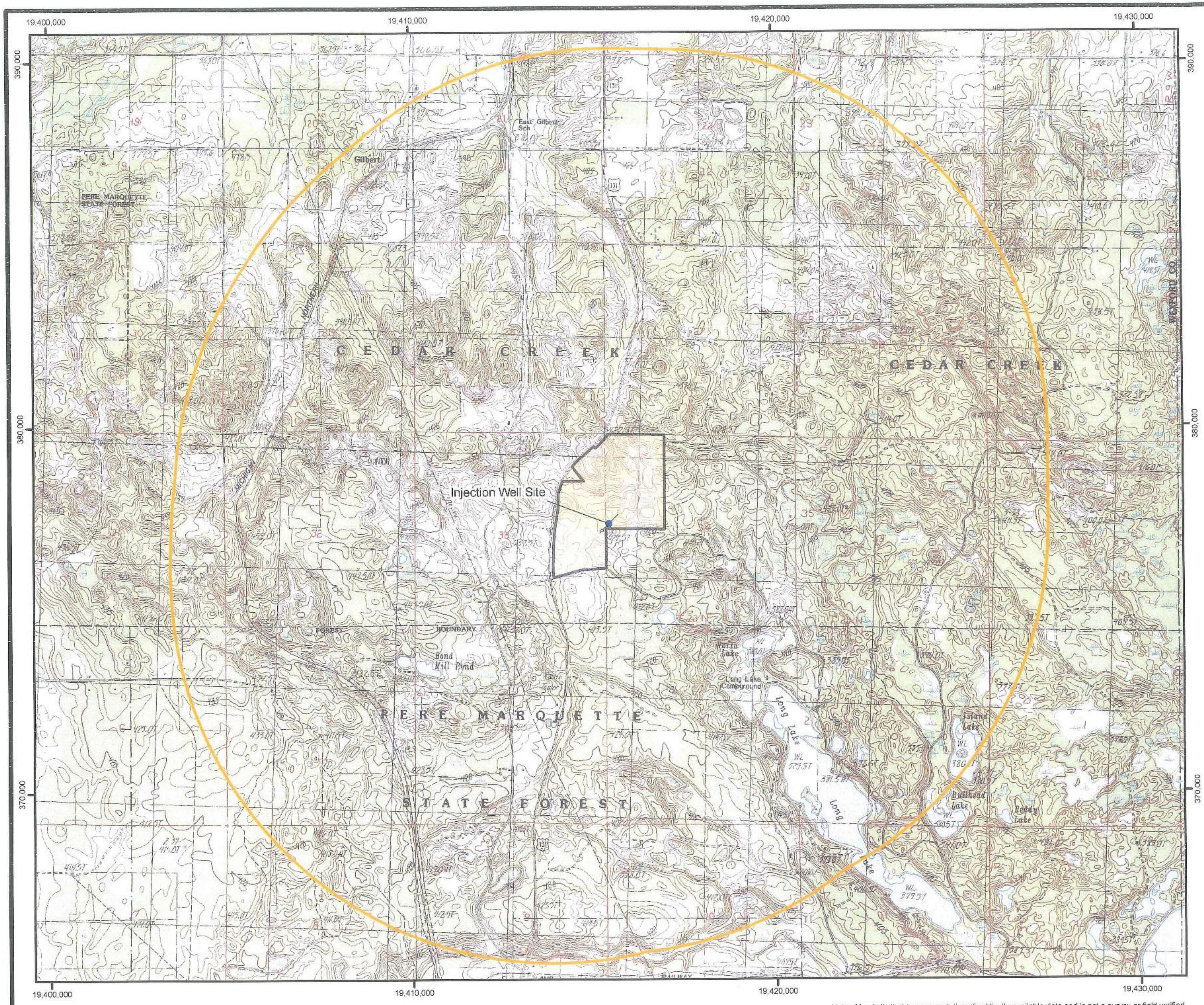
303-290-9414
www.petrotek.com



Legend

- Injection Well Site
- 2 Mile AOR
- Wexford Property Boundary

0 2,000 4,000 6,000 Feet

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Wexford Water Technologies, LLC

990 N US Highway 131, Manton, MI 49663

Figure B-3
Topographic Map

2015 Wexford Well No.1 Permit Application

Scale: 1:31,680	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_B-03.mxd	By: JLM Checked: CW

Petrotek
5935 South Zang Street, Suite 200
Littleton, Colorado 80127 USA
303-290-9414
www.petrotek.com

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Property Owners
- Wexford Property Boundary
- Injection Well Site

TAXID_SHRT	NAME1
33-4111	MOCABY, GUY L & JILL
33-4110	BYRNE LAND CORP INC
33-1401	WEXFORD COUNTY LANDFILL LLC
33-4201	GATES, JAMES F
27-3401	CIALEK, MICHAEL ETAL
27-3301	CASSONE, ANTONIO TRUST
33-1104	DOAN, DANIEL L & DONNA M
33-1105	KUHNS, STEVEN L
33-1106	TOLES, ROBERT J
33-1207	MDOT
33-4203	GATES, JAMES
33-4204	GATES, JAMES
33-4206	VANDAM LAND CO LLC
33-4209	BIGELOW, CHARLES C
34-3101	MANTON SCHOOL
34-1101	STATE OF MICHIGAN
33-4103	RETLEWSKI, GREGORY A & KATHERINE
33-4104	MOCABY, GUY & JILL
33-4109	MID STATES LAND LC
28-4401	CASSONE, ANTONIO TRUST
33-1101	LESLEY, DAVID & PATRICE OHNSMAN
ROW	
ROW	

0 1,000 2,000 Feet

Wexford Water Technologies, LLC

990 N US Highway 131, Manton, MI 49663

Figure B-4
Property Owners Adjacent to Wexford Property Boundary

2015 Wexford Well No.1 Permit Application

Scale: 1:10,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_B-04.mxd	By: JLM — Checked: CW

Petrotek

2.C CORRECTIVE ACTION PLAN AND WELL DATA

Submit a tabulation of data reasonably available from public records or otherwise known to the applicant on all wells within the area of review, including those on the map required in Section 2.B, which penetrate the proposed injection zone. Such data shall include the following:

Class I

A description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Director may require. In the case of new injection wells, include the corrective action proposed to be taken by the applicant under 40 CFR 144.55.

Response:

CORRECTIVE ACTION

There is one artificial penetration to the depth of any of the proposed injection zones within the two mile area of review. Well construction and abandonment information for this well, the George Wilcox No. 1 (Well Permit No. 12415), are included in Appendix C.1. The well was drilled to the top of the Detroit River Formation. The well was abandoned following regulatory requirements in place at the time. The well bore was filled with mud from TD (4010.5 ft below surface) to ground surface, with an 8' cement cap placed at ground surface. The 8-5/8" casing was cemented in place to 881 feet and 63 ft of 16" casing was cemented in place; these casings were not removed during abandonment and remain in place, thus isolating the glacial drift and a thin (11 ft) Saginaw sand behind pipe. In this well the Glacial Drift is isolated, and if the Saginaw is a USDW, it too is isolated with cemented casing set below this formation. Based on the presence of drilling mud in the well, the cemented casing and cap in place from 881 feet to surface, and COI calculations presented in Section 2.A, there exists no pathway or potential for fluid to move from any proposed injection zone into the USDW, even if a measureable pressure rise were to occur within one of the proposed injection zones at the location of this well. Therefore no corrective action plan is currently proposed. The corrective action plan which would be proposed by WWT, should fluid migration occur through the confining layer, will include the following:

1. The Well No. 1 disposal well will be shut-in.
2. The US EPA, Region 5 UIC Section and the Michigan Department of Natural Resources will be notified.
3. Following well shut-in, waste will be shipped to alternative permitted facilities for off-site treatment and disposal as necessary.
4. A contingency plan will be prepared as follows:

a. Locate well and identify present operator or owner, if any.

b. Identify mode of failure.

c. Prepare remedial plan outlining course of action.

d. The remedial plan will be submitted to MDEQ and US EPA, Region 5 for approval.

e. Upon authorization, the remediation plan will be implemented.

Area of Review Well Data

Appendix C.1 (CD-ROM) at the end of Section 2.C includes copies of well records for deep artificial penetrations within the two mile area of review; a single deep well that penetrates to the proposed injection zone is found in the two mile AOR. Although not required, additional data for wells within a five mile radius are also included in Appendix C.1 (CD-ROM) for informational purposes. Well locations are shown on Figure B-1. Permitted Oil and gas wells drilled into the injection zone and subsequently abandoned, wells drilled into the injection zone that are still active producers, and temporarily abandoned wells that penetrate to the injection zone are listed in Tables C-1 and C-2, again showing there to be a single well of interest in the two mile AOR. Wells are identified by MDEQ permit numbers, location, total depth, status, construction and completion or plugging date.

In addition to deep well file data, Appendix C.1 (CD-ROM) at the end of Section 2.C presents copies of water well data within a one mile radius of the Wexford County Landfill, as well as well construction information for monitoring wells near the Wexford County Landfill. Data were obtained from online, publicly available records from the Michigan Department of Natural Resources, Geological Survey Division in Lansing, Michigan, as well as from the Hydrogeologic Monitoring Plan (May, 2008), and other sources.

Table C-1
Artificial Penetrations: MDEQ Oil and Gas Permits Active Permits Penetrating to Injection Zone within 2 Miles AOR

MDEQ Permit #	Well Location			Total Depth (ft. BGL)	Date of Completion or P&A	Permit Data	Casing	
	Twn	Rng	Sec				Depth	Cement
12415	23N	09W	32	4,010.5	P/A: 8/21/1946	O&G	63' 881'	50 sx 350 sx
35335	23N	09W	20	Not Drilled	Application to drill 12/10/81 Permit Cancelled 12/29/82	Not Drilled	Not Drilled	Not Drilled

Notes:
P&A = dry hole, plugged
O&G = Oil/Gas Well

Casing information for the single deep well within the 2 mile AOR, the George Wilcox No. 1 (Permit 12415), is presented in table C-1. The cemented 8-5/8" string extends to 881 feet, terminating in the limestone of the Michigan Formation and thus isolating the thin (11 foot) Saginaw Formation sand (possible USDW assigned as lowermost USDW) and overlying Glacial Drift (known to be USDW locally); this well completion method isolates the USDW from deeper intervals. In this well the Glacial Drift is isolated, and if the Saginaw is a USDW, it too is isolated with cemented casing set below this formation. Based on the presence of drilling mud in the openhole of the well from 881 feet to TD, the cemented casing and cap in place from 881 feet to surface, and COI calculations presented in Section 2.A there exists no pathway or potential for fluid to move from any proposed injection zone into the USDW, even if a measureable pressure rise were to occur within one of the proposed injection zones at the location of this well. Table C-2 presents additional information about the George Wilcox No. 1 well.

There are approximately 60 water wells within an approximately one mile radius of the Wexford County Landfill property boundary, as shown in Figure B-2a. Figure B-2b shows there are 77 monitoring wells in the area, most of which are north of the Wexford County Landfill. Table C-3 presents information about the water wells. It should be noted that a number of domestic wells were plugged and abandoned when the residences were placed on a local public water supply; these wells are not listed. Table C-4 presents information about the monitoring wells, and shows that twelve (12) of these wells are included in the Quarterly Monitoring Report submitted by the landfill operator as part of its Hydrogeological Monitoring Program. The remaining monitoring wells are under the purview of Wexford County and were installed to monitor and purge existing groundwater contamination.

Table C-2
MDEQ Oil & Gas P&A Data for Wells Penetrating to Injection Zone Within 2-Mile AOR

MDEQ Permit#	Well Location			Total Depth (ft. BGL)	Date of Compl. or P&A	Permit Data	Casing		Plugging	
	Twn	Rng	Sec				Depth	Cement	Depth Placed	Cement
12415	23N	9W	32	4010.5	8/21/46	PTD issued June 24, 1946. Oil and gas exploratory well	16" to 63' 8 5/8 to 881'	50 SX 350 SX Dowell	Mud pumped from TD to surface as drill pipe laid down. After pipe pulled, loaded hole again with mud; 8 5/8" and 16" casing abandoned in place in the hole.	Cement cap placed in and on top of the 8-5/8" casing at surface.

Notes:
Date = completion or plugging.
P&A = dry hole, plugged

Table C-3 presents a summary of water well records available in the MDEQ database. These wells are all shown on Figure B-2a. Table C-4 presents monitoring well information for wells shown on Figure B-2b.

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
Wells Within ¼ Mile of the Property										
83000003370[2]	Sec 33 23N09W	Wexford Co. D.P.W.	339	11/4/2003	334	335	339	3 hrs. at 15 GPM	245ft	Gravel and Sand Medium Fine
83000002426[2]	Sec 33 23N09W	Gregory A. Retlewski	200	6/3/2001	195	195	200	Pumping level 180 ft. after 1 hr. at 12 GPM.	147ft	Sand
83000002359[2]	Sec 33 23N09W	Robert Blackledge	264	1/2/2001	260	260	264		240ft	Tan Sand Medium to Coarse
83000001943	Sec 33 23N09W	Larry and Paula Smith/North Co	266	10/4/1994	261	261	266	Pumping level 260.00 ft. after 3.00 hrs. at 12 GPM	243ft	Sand
83000002383[2]	Sec 33 23N09W	Leroy & Marilyn Atkinson	225	11/8/2000	220	221	225		183ft	Sand Medium
83000004140	Sec 33 23N09W	Alex Giftos	285	6/20/2004	280	280	285	Pumping level 260.00 ft. after 1.00 hrs. at 14 GPM	190ft	Sand & Gravel
83000002967	Sec 33 23N09W	Guy L. Mocaby	215	1/31/2003	210	212	215	Pumping level 200.00 ft. after 1.00 hrs. at 12 GPM	175ft	Sand & Gravel
83000004749	Sec 27 23N09W	Guy & Beth Hissong	402	6/28/2005	398	398	402	Pumping level 185.00 ft. after 0.50 hrs. at 30 GPM	180ft	Tan Sand Medium To Coarse
Wells Within 1-Mile of the Property										
83000003233	Sec 3 22N09W	MDNR Long Lake CG -A	no data	no data	no data	no data	no data	no data		no data

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
83000002399	Sec 4 22N09W	Mark Sangren	174	2/19/2001	167	167	174	170ft	153ft	Sand and Gravel stringers
83000003168	Sec 4 22N09W	Dan & Rosa Bush	185	6/17/2003	181	181	185	Pumping level 152.00 ft. after 0.50 hrs. at 40 GPM	145ft	Tan Sand Medium to Coarse
83000004966	Sec 4 22N09W	John Welch	183	12/16/2005	176	176	183	Pumping level 175.00 ft. after 1.00 hrs. at 12 GPM	158ft	Sand Medium
83000004975	Sec 4 22N09W	Dan Bush	200	12/5/2005	196	196	200	Pumping level 157.00 ft. after 0.50 hrs. at 20 GPM	154ft	Tan Sand Medium To Coarse
83000003032	Sec 21 23N09W	Borin Enterprises	100	9/19/2001	96	96	100	Pumping level 74.00 ft. after 0.50 hrs. at 15 GPM	70ft	Tan Sand Medium
83000002209	Sec 22 23N09W	Brian Friday	159	1/31/2002	155	155	159	Pumping level 130.00 ft. after 0.50 hrs. at 10 GPM	130ft	Tan Sand and Gravel
83000002397	Sec 22 23N09W	Jill E. Haney	185	6/30/2000	180	180	185	Pumping level 175.00 ft. after 1.00 hrs. at 12 GPM	160ft	Sand & Gravel
83000004368	Sec 22 23N09W	Bennett Real Estate	146	11/17/1973	143	143	146	Pumping level 126.00 ft. after 2.00 hrs. at 7 GPM	126ft	Sand

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
83000004856	Sec 22 23N09W	Walt & Linda Mohler	402	11/17/2005	398	398	402	Pumping level 136.00 ft. after 0.50 hrs. at 15 GPM	133ft	Tan Sand Medium To Coarse
83000005365	Sec 26 23N09W	Wexford County BPW	440	2/27/2008	438	434	438	Pumping level 340.00 ft. after 1.00 hrs. at 30 GPM	130ft	Sand
83000005367	Sec 26 23N09W	Wexford County BPW	424	2/5/2008	420	420	424	Pumping level 360.00 ft. after 1.00 hrs. at 15 GPM	130ft	Sand
83000001307	Sec 27 23N09W	Heidi Cook, Thad Holton	255	9/25/1995	248	250	255		106ft	Tan Sand
83000001308	Sec 27 23N09W	Ron Dextrom	240	9/11/1995	235	235	240	Pumping level 200.00 ft. after 4.50 hrs. at 60 GPM	135ft	Sand Wet/Moist
83000001309	Sec 27 23N09W	Marianne & Phil Howes	169	8/17/1995	162	164	169		133ft	Sand & Gravel
83000001310	Sec 27 23N09W	Lohman, Robert James	259	10/11/1995	259	254	259	Pumping level 225.00 ft. after 6.00 hrs. at 60 GPM	155ft	Sand Wet/Moist
83000001311	Sec 27 23N09W	Brian Bell	385	6/19/1996	380	381	385		140ft	Light Brown Sand & Gravel Fine
83000001312	Sec 27 23N09W	Deborah Westveer	203	9/3/1998	198	198	203	Pumping level 0.00 ft. after 1.00 hrs. at 15 GPM	175ft	Sand Wet/Moist

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
83000002011	Sec 27 23N09W	William J. Mead	160	7/24/1993	155	155	160	Pumping level 128.00 ft. after 1.00 hrs. at 38 GPM	120ft	Sand
83000002053	Sec 27 23N09W	Richard Coykendall	180	6/15/1992	175	175	180	Pumping level 156.00 ft. after 2.00 hrs. at 38 GPM	154ft	Sand Water Bearing
83000002073	Sec 27 23N09W	Bill Meade	150	7/24/1993	145	145	150	Pumping level 115.00 ft. after 1.00 hrs. at 30 GPM	115ft	Sand
83000002159	Sec 27 23N09W	MM Arden J. Hill	168	8/1/2000	168	163	168	Pumping level 150.00 ft. after 0.50 hrs. at 50 GPM	145ft	Gravel & Sand
83000004370	Sec 27 23N09W	Karen Danford	210	4/29/1989	205	205	210	Pumping level 168.00 ft. after 2.00 hrs. at 25 GPM	168ft	Sand & Gravel
83000004830	Sec 27 23N09W	Cory Danford	176	8/22/2005	172	172	176	Pumping level 146.00 ft. after 0.50 hrs. at 20 GPM	142ft	Tan Sand Medium To Coarse
83000004851	Sec 27 23N09W	Cory Danford	175	10/10/2005	171	171	175	Pumping level 146.00 ft. after 0.50 hrs. at 20 GPM	143ft	Tan Sand Medium To Coarse
83000004969	Sec 27 23N09W	Cory Danford	188	1/4/2006	184	184	188	Pumping level 155.00 ft. after 0.50 hrs. at 20 GPM	150ft	Tan Sand Medium To Coarse

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
83000005005	Sec 27 23N09W	Helen Clark	425	3/19/2006	420	420	425	Pumping level 128.00 ft. after 0.50 hrs. at 15 GPM	123ft	Tan Sand Medium To Coarse
83000005015	Sec 27 23N09W	Roger & Elisabeth Grames	425	4/14/2006	420	420	425	Pumping level 184.00 ft. after 0.50 hrs. at 15 GPM	180ft	Tan Sand Medium To Coarse
83000005089	Sec 27 23N09W	Eugene Bergey	390	9/7/2006	385	385	390	Pumping level 110.00 ft. after 0.50 hrs. at 15 GPM	108ft	Tan Sand Medium To Coarse
83000005612	Sec 27 23N09W	Jason Sherman	195	7/16/2009	190	191	195	2.00 hrs. at 25 GPM	124ft	Sand & Gravel
83000001313	Sec 28 23N09W	Brad Grames	130	no data	130	no data	no data	Pumping level 100.00 ft. after 1.00 hrs. at 15 GPM	80ft	Sand
83000001314	Sec 28 23N09W	Douglas Field	148	8/6/1996	144	144	148		125ft	Tan Sand Medium To Coarse Water Bearing
83000001315	Sec 28 23N09W	George Schomber	130	8/27/1996	126	126	130		105ft	Tan Sand Medium To Coarse
83000002136	Sec 28 23N09W	Gordon & Wendy Young	220	5/22/2001	216	216	220	Pumping level 190.00 ft. after 0.50 hrs. at 10 GPM	190ft	Tan Sand Medium To Coarse Sandy
83000002270	Sec 28 23N09W	Timothy & Heather Lewis	200	9/7/2000	195	195	200		172ft	Tan Sand Medium To Coarse

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
83000002855	Sec 28 23N09W	Don Badoun	198	6/27/2002	194	192	198	Pumping level 165.00 ft. after 0.50 hrs. at 50 GPM	150ft	Tan Sand Medium To Coarse
83000002924	Sec 28 23N09W	Shawnee M. Horn	170	10/29/2001	166	166	170	Pumping level 145.00 ft. after 0.50 hrs. at 20 GPM	139ft	Tan Sand Medium To Coarse
83000003875	Sec 28 23N09W	Cory & Aimee Danford	218	6/7/2004	214	214	218	Pumping level 189.00 ft. after 0.50 hrs. at 20 GPM	185ft	Tan Sand Medium To Coarse
83000004709	Sec 28 23N09W	Jon Bennett	305	4/22/2005	299	299	305	Pumping level 155.00 ft. after 1.00 hrs. at 10 GPM	145ft	Brown Sand Medium To Coarse
83000005500	Sec 28 23N09W	Melvin Johnson	167	9/23/2008	162	162	167	Pumping level 90.00 ft. after 0.25 hrs. at 30 GPM	90ft	Sand
83000002325	Sec 32 23N09W	David Renfer	265	6/11/2000	257	257	265	1.00 hrs. at 12 GPM	235ft	Sand Water Bearing
83000003187	Sec 32 23N09W	Jerry & Jody Roth	295	6/30/2003	291	291	295	Pumping level 241.00 ft. after 0.50 hrs. at 30 GPM	238ft	Tan Sand Medium To Coarse
83000004657	Sec 32 23N09W	Roger and Barbara Hatfield	285	8/25/2001	280	280	285	Pumping level 248.00 ft. after 2.00 hrs. at 15 GPM	241ft	Sand

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
83000002186	Sec 33 23N09W	Dennis Crouse	44	10/18/2001	40	40	44	Pumping level 14.00 ft. after 0.50 hrs. at 15 GPM	14ft	Tan Sand W/Gravel
83000002573	Sec 33 23N09W	Richard Cruson	290	10/12/2001	285	285	290	Pumping level 185.00 ft. after 1.00 hrs. at 20 GPM	185ft	Sand
83000003074	Sec 33 23N09W	Guy L. Mocaby	215	1/31/2003	210	210	215	Pumping level 200.00 ft. after 1.00 hrs. at 16 GPM	173ft	Sand & Gravel
83000003494	Sec 33 23N09W	Jonathon & Shelli Sherman	258	3/5/2004	254	254	258	Pumping level 211.00 ft. after 0.50 hrs. at 20 GPM	209ft	Tan Sand & Gravel Medium To Coarse
83000005364	Sec 35 23N09W	Wexford County BPW	425	2/27/2008	400	400	405	Pumping level 400.00 ft. after 1.00 hrs. at 30 GPM	180ft	Sand & Gravel
83000004763	Sec 27 23N09W	Cory Danford	180	7/14/2005	176	176	180	Pumping level 145.00 ft. after 0.50 hrs. at 20 GPM	141ft	Tan Sand Medium To Coarse
83000006245	Sec 28 23N09W	Joey Olson	150	7/7/2014	146	146	150	Pumping level 97.00 ft. after 0.50 hrs. at 15 GPM	94ft	Rust Sand Medium To Coarse
83000006156	Sec 26 23N09W	William Light	175	10/22/2013	171	171	175	Pumping level 127.00 ft. after 1.00 hrs. at 20 GPM	120ft	Tan Sand & Gravel Fine To Coarse

Table C-3
Water Wells Located in 1 Mile Radius of Facility[1]

Well ID#	Location	Owner Name	Well Depth (ft)	Construction Date	Case Depth (ft BGL)	Screen From (ft BGL)	Screen to (ft BGL)	Yield (if available)	Static Water Level	Producing Formation (if available)
83000005986[2]	Sec 23 23N09W	Rita McNamara	200	5/10/2012	196	196	200	0.50 hrs. at 15 GPM	145ft	Brown Sand Medium to Coarse

1 Figure B-2a presents water well locations as modified from Golder, 2012.

2 Wells identified by footnote were added to the Golder, 2012 map because they were either within the property boundary (3370, 2426, 2359) or were added to the MDEQ database since the Golder, 2012 map was constructed (5986).

Table C-4
Monitoring Wells Located in the WWT Well No. 1 Area

Well Information			Location		Elevations		Screen Interval			
Well	Other Well Information	Total Depth* (feet)	Coordinates		Grade Elevation	Top of Casing Elevation	Screen Length	Bottom of Screen	Depth From Ground Surface to Bottom of Screen**	Top of Screen
			Northing	Easting	ft/msl	ft/msl	feet	ft/msl	ft/bgl	ft/msl
Wells in Hydrogeologic Monitoring Plan										
MW-1[2] (Office Supply Well)	Upper Sand-Potable	188	9881.50	8910.19	1,384.6	1,383.42	4	1,197.0	187.6	1,201
MW-2R[1,2]	Upper Sand	203	8171.70	10113.90	1,415.08	1,418.00	5	1,215.0	200.08	1,220
MW-3R[1]	Background Well	180	7442.70	9422.12	1,388.26	1,392.06	5	1,212.0	176.26	1,217
MW-4[1]	Upper Sand	244	8678.93	8843.78	1,441.3	1,445.29	4	1,216.0	225.3	1,220
MW-5	Upper Sand	260	8681.44	8841.29	1,441.9	1,443.89	3	1,201.0	240.9	1,204
MW-6[1]	Upper Sand	230	9027.45	8794.52	1,438.8	1,439.93	3	1,204.0	234.8	1,207
MW-7R[1]	Upper Sand	230	9418.80	8849.59	1,413.0	1,415.49	4	1,186.0	227.0	1,190
MW-8[1]	Upper Sand	200	9638.44	9474.59	1,409.1	1,411.97	3	1,201.0	208.1	1,204
MW-9R[1]	Upper Sand	280	9996.06	9703.52	1,452.42	1,455.72	5	1,173.0	279.42	1,178
MW-10[1]	Upper Sand	251	9601.61	9867.65	1,434.3	1,436.47	3	1,187.0	247.3	1,190
MW-11[1]	Upper Sand	234	10020.54	9067.73	1,403.6	1,406.07	3	1,172.0	231.6	1,175
MW-12[1]	Background Well	203	6836.17	9906.70	1,382.5	1,385.62	4	1,180.0	202.5	1,184
MW-25[1] (Shop Supply Well)	Lower Sand - Potable	339	7744.03	8766.06	1,447.7	1,449.89	4	1,109.0	338.7	1,113
MW-26[1,2]	Lower Sand	319	6191.48	10104.26	1,414.1	1,417.68	5	1,116.0	298.1	1,121
MW-36[1]	Lower Sand	320	9995.00	8067.0	1,405.6	1,408.26	5	1,113.0	292.6	1,118
MW-54	Background Well		TBD	TBD	TBD	TBD	5	TBD	TBD	TBD
PW-1	Purge Well	248	10024.23	8827.77	1,381.5	1,383.24	40	1,167.0	214.5	1,207

Table C-4
Monitoring Wells Located in the WWT Well No. 1 Area

Well Information			Location		Elevations		Screen Interval			
Well	Other Well Information	Total Depth* (feet)	Coordinates		Grade Elevation	Top of Casing Elevation	Screen Length	Bottom of Screen	Depth From Ground Surface to Bottom of Screen**	Top of Screen
			Northing	Easting	ft/msl	ft/msl	feet	ft/msl	ft/bgl	ft/msl
PW-2	Purge Well	No data	10017.03	8963.95	1,391.6	1,393.95	40	1,166.0	225.6	1,206
PW-3	Purge Well	248ft	10010.90	9105.79	1,409.1	1,410.81	40	1,161.0	248.1	1,201
PW-4	Purge Well	246ft	10007.08	9244.65	1,407.3	1,408.29	40	1,172.0	235.3	1,212
PW-5	Purge Well	246ft	10002.16	9383.86	1,425.8	1,428.74	40	1,168.0	257.8	1,208
Additional Wells										
MDOT		270.3	12207.26	7737.41	1,392.1	1,393.2	5	1,121.8	270.3	1,126.8
MW-2 (abandoned)		206	8225.59	9902.18	1,437.0	1,438.53	4	1,231.0	206.0	1,235
MW-15		260	10772.72	8742.9	1,363.9	1,368.83	3	1,103.9	260.0	1,106.9
MW-16		260	10911.28	9246.98	1,376.1	1,379.46	3	1,138.1	238.0	1,141.1
MW-17		250	11729.33	9373.77	1,363.8	1,367.22	3	1,113.8	250.0	1,116.8
MW-18		254	11279.34	9641.1	1,359.7	1,363.12	3	1,105.7	254.0	1,108.7
MW-27		239	11739.72	9059.11	1,340.6	1,343.98	5	1,101.6	239.0	1,106.6
MW-28		298	10899.10	9155.82	1,363.7	1,366.44	5	1,147.7	216.0	1,152.7
MW-29		257	11892.70	9432.97	1,359.2	1,362.41	5	1,124.2	235.0	1,129.2
MW-30		229	11196.83	9250.28	1,359.8	1,362.76	5	1,130.8	229.0	1,135.8
MW-31		257	11562.98	8623.71	1,359.2	1,362.41	5	1,124.2	235.0	1,129.2
MW-32D		244	14643.58	9693.27	1,314.5	1,315.52	15	1,129.8	184.7	1,144.8
MW-32M		151	14643.50	9693.3	1,313.3	1,316.04	15	1,165.0	148.3	1,180
MW-33		239	14392.10	8329.5	1,335.6	1,338.09	10	1,147.0	188.6	1,157
MW-34		290	12100.60	8165.8	1,376.4	1,375.97	10	1,133.0	243.4	1,143
MW-35M	Medium Sand	155	15050.86	8130.36	1,294.9	1,297.68	10	1,139.9	155.0	1,149.9

Table C-4
Monitoring Wells Located in the WWT Well No. 1 Area

Well Information			Location		Elevations		Screen Interval			
Well	Other Well Information	Total Depth* (feet)	Coordinates		Grade Elevation	Top of Casing Elevation	Screen Length	Bottom of Screen	Depth From Ground Surface to Bottom of Screen**	Top of Screen
			Northing	Easting	ft/msl	ft/msl	feet	ft/msl	ft/bgl	ft/msl
MW-35D	Medium to coarse tan sand	205	15049.8	8151.2	1,293.2	1,296.31	10	1,103.0	190.2	1,113.0
MW-35L		221	15040.8	8156.6	1,292.5	1,295.34	5	1,071.5	221.0	1,076.5
MW-37		305	11919.29	11290.586	1,401.1	1,403.84	10	1,140.0	261.1	1,150.0
MW-37L		371	11917.54	11271.27	1,401.8	1,404.16	5	1,030.8	371.0	1,035.8
MW-39		356	9976.19	9803.928	1,457.7	1,460.53	5	1,138.0	319.7	1,143.0
MW-38		239.7	13205.09	9924.497	1,340.7	1,342.36	10	1,101.0	239.7	1,111.0
MW-40		299	1389.895	9257.811	1,389.9	1,392.15	10	1,158.1	231.8	1,168.1
MW-41	Light Brown Sand	349	9995.8	9414.8	1,425.0	1,430.28	10	1,150.0	275.0	1,160.0
MW-43D		280.5	14037.09	7887.612	1,330.1	1,336.01	10	1,070.0	260.1	1,080.0
MW-43M		190	14033.81	7866.296	1,330.0	1,332.11	10	1,140.0	190.0	1,150.0
MW-44M		220	16634.24	8924.025	1,324.5	1,327.58	10	1104.5	220.0	1,114.5
MW-44D		270	16634.29	8944.961	1,325.1	1,328.24	10	1,074.0	251.1	1,084.0
MW-45M		157	16613.65	9933.309	1,326.7	1,329.59	10	1,169.7	157.0	1,179.7
MW-45D		251	16614	9954.423	1,326.7	1,329.24	10	1,098.0	228.7	1,108.0
MW-46M		151	16930.79	10840.27	1,310.6	1,313.24	10	1,161.8	148.8	1,171.8
MW-46D		233	16927.08	10857.53	1,311.0	1,313.8	10	1,103.0	208.0	1,113.0
MW-46L		242	16938.65	10854.06	1,310.7	1,312.96	5	1,068.7	242.0	1,073.7
MW-47D		275	13800.81	10937.88	1,354.8	1,358.1	10	1,101.0	253.8	1,111.0
MW-47M		194	13800.73	10960.54	1,354.1	1,357.03	10	1,160.1	194.0	1,170.1
MW-48D		357	9556.40	11038.5	1,406.1	1,408.74	10	1,049.1	357.0	1,059.1

Table C-4
Monitoring Wells Located in the WWT Well No. 1 Area

Well Information			Location		Elevations		Screen Interval			
Well	Other Well Information	Total Depth* (feet)	Coordinates		Grade Elevation	Top of Casing Elevation	Screen Length	Bottom of Screen	Depth From Ground Surface to Bottom of Screen**	Top of Screen
			Northing	Easting	ft/msl	ft/msl	feet	ft/msl	ft/bgl	ft/msl
MW-48M		220.1	9550.50	11043.1	1,405.7	1,409.06	10	1,185.6	220.1	1,195.6
MW-49M	Brown sand fine to medium	106	16502.7	7522.2	1,249.3	1,252.01	5	1,145.3	104.0	1,150.3
MW-49D	Sand fine	156	16514.7	7525.8	1,249.8	1,252.71	5	1,097.8	152.0	1,102.8
MW-50		148	10613.00	9216	1,345.5	1,347.97	10	1,197.5	148.0	1,207.5
MW-51L		265	12036.74	8809.61	1,341.8	1,345.18	5	1,076.8	265.0	1,081.8
MW-52	Sand - Coarse	217	8443.90	8235.9	1,427.3	1,430.3	10	1,210.3	217.0	1,220.3
MW-52L	Tan, Sand and Gravel	341	8457.8	8231.6	1,427.8	1,430.56	5	1,087.0	341.0	1,092
MW-53	Sand, fine to coarse, layered	410	7627.7	10218	1,419.4	1,422.12	5	1,011.4	408.0	1,016.4
MW-61M	Sand	155	17994.6	8038.1	1,293.1	1,295.39	5	1,140.1	153.0	1,145.1
MW-61D	Sand	199	17992	8048.8	1,292.8	1,294.8	5	1,099.8	193.0	1,104.8
MW-62M	Sand and gravel	181	20419.4	10929.1	1,319.9	1,322.23	5	1,138.9	181.0	1,143.9
MW-62D	Red sand, fine to coarse, layered	257	20421	10917	1,319.5	1,322.69	5	1,065.5	254.0	1,070.5
MW-63M	Sand and gravel	168	20449.3	9602.7	1,316.6	1,318.84	5	1,148.6	168.0	1,153.6
MW-63D	Sand and gravel	246	20448.7	9590.5	1,316.2	1,318.16	5	1,073.2	243.0	1,078.2
MW-64M	Sand	174	20799.6	8202.8	1,301.4	1,304.05	5	1,129.4	172.0	1,134.4
MW-64D	Sand	230	20798.2	8189.9	1,302.0	1,304.54	5	1,078	224.0	1,083.0
MW-1358		253	11788.33	9864.59	1,398.47	1,399.66	5	1,145.5	253.0	1,150.5
MW-1729		240	13820.46	8891.54	1,346.9	No data	5	1,106.9	240.0	1,111.9

Table C-4
Monitoring Wells Located in the WWT Well No. 1 Area

Well Information			Location		Elevations		Screen Interval			
Well	Other Well Information	Total Depth* (feet)	Coordinates		Grade Elevation	Top of Casing Elevation	Screen Length	Bottom of Screen	Depth From Ground Surface to Bottom of Screen**	Top of Screen
			Northing	Easting	ft/msl	ft/msl	feet	ft/msl	ft/bgl	ft/msl
MW-NBW (1260 – 131)		385	No data	No data	1,358.3	No data	N/A	973.3	N/A	N/A
MW-OBW		0	11363.78	9334.82	1,358.3	1,359.57	5	1,358.3	0	1,363.3

* From Drillers Report
** From Hydrogeologic Monitoring Plan Table 1
1 Wells included in Wexford County Landfill Quarterly Monitoring Report
2 Abandoned

References:

Golder Associates, 2012, Hydrogeologic Report, Wexford County Landfill, Prepared for Wexford County Landfill, LLC

2.D MAPS AND CROSS SECTIONS OF USDWs

Submit maps and cross sections indicating the vertical limits of all underground sources of drinking water within the area of review (both vertical and lateral limits for Class I), their position relative to the injection formation and the direction of water movement, where known, in every underground source of drinking water which may be affected by the proposed injection activities.

Response:

Figure D-1a shows the hydrostratigraphic column for the Wexford area. Ground water with TDS values of less than 10,000 ppm is considered an Underground Source of Drinking Water (USDW) by EPA for the purpose of UIC permitting activities, and in the Wexford County area potable water (<10,000 mg/l TDS) is available in the Pleistocene glacial drift (Quaternary). According to public records, all water wells within one mile of the Wexford County Landfill property are completed within the Glacial Drift.

Hydrogeology of Wexford County

According to the USGS (2007), Glacial Drift deposits in Wexford County range in thickness from 201 ft to greater than 1,000 ft [(Western Michigan University (WMU), 1981)] and are composed of outwash, till, and lacustrine deposits (Stewart, 1948; Farrand and Bell, 1982). The Lake Border Moraine covers the majority of Wexford County while the Valparaiso and Charlotte Moraines are present in southeastern portions of the County (USGS, 2007); sand/gravel lacustrine deposits are also present. Stewart (1948) indicates that sand dunes are common on the surface of glacial features throughout the county. Figure D-1b is a glacial drift map of Wexford County.

Glacial aquifers consist of sand and gravel that are part of a thick sequence of Pleistocene glacial deposits (Westjohn and others, 1994). The sand and gravel glacial drift aquifers supply water to the City of Cadillac and other users in Wexford County (Baltusis and others, 1992, Westjohn and others, 1994). The USGS (2007) states that there are three sand-and-gravel aquifers in the Cadillac area, with clay-confining units separating the aquifers (Hoard and Westjohn, 2005). The USGS (2007) concludes:

> "Based on aquifer test results for the City of Cadillac, the deep aquifer, which is over 265 feet below the ground surface, has a hydraulic conductivity of 214 ft/day... aquifer tests (were conducted) for production wells in Haring Township, which is just north of the City of Cadillac. These tests indicate that the deep aquifer underlying Haring Township has similar hydraulic properties to the deep aquifer underlying Cadillac. Results from other aquifer tests within the Cadillac area indicate horizontal hydraulic conductivities ranging from 43 to 163 ft/d for the shallow and intermediate aquifers in the glacial deposits and a vertical hydraulic conductivity of 0.031 ft/day for the clay-confining unit between the intermediate and

deep glacial aquifers (Hoard and Westjohn, 2005). According to the Public Water Supply database, the estimated transmissivity, based on aquifer tests, for glacial wells ranges from approximately 2,265 to 51,895 ft^2/day."

The USGS (2007) also states that bedrock below Glacial Drift in Wexford County includes subcropping Saginaw Formation, Bayport Limestone, Michigan Formation, Marshall Sandstone, and Coldwater Shale (Milstein, 1987) (Figure D-1c). The USGS states "These bedrock units have not been used for water supply because the overlying glacial deposits which consist predominantly of permeable sand and gravel provide enough water for industrial, commercial, and domestic uses (Hoard and Westjohn, 2005)".

The Saginaw Formation subcrops in the southeastern portion of the county and, where present, is composed of interbedded sandstone, siltstone, shale, coal, and lesser limestone. "Hydraulically connected sandstones" within the Saginaw are considered the Saginaw aquifer (Westjohn and Weaver, 1996a). The Saginaw "aquifer" is 100-370 feet thick, and yields saline water where it does not subcrop beneath glacial drift, but according to Westjohn and Weaver (1996a), the Saginaw aquifer can contain fresh water in portions of Wexford County (Westjohn and Weaver, 1996b) where it subcrops immediately below glacial drift. The basal portion of the Saginaw is a shale-rich confining unit that is approximately 100 to 240 ft thick within the State.

The Parma-Bayport sandstone occurs below the Saginaw confining unit and is sometimes considered the basal unit of the Saginaw Formation (USGS, 2007). The USGS (2007) states:

> "The Parma Sandstone is composed of medium- to coarse-grained sandstone, and is generally less than 100 ft thick.... The Bayport Limestone is a fossiliferous, cherty limestone, often with interbedded sandstone and varies considerably in thickness from one area to another. The Bayport Limestone and Parma Sandstone appear to interfinger throughout the Michigan Basin (Westjohn and Weaver, 1996a). These units are hydraulically connected, and together they form the Parma-Bayport aquifer (Westjohn and Weaver, 1996a). The Parma-Bayport aquifer is approximately 100 to 150 ft thick within the Michigan Basin. The Parma-Bayport aquifer contains fresh and saline water in Wexford County".

The Michigan Formation occurs below the Bayport Limestone and is composed of sandstone, shale, limestone, gypsum, anhydrite and occasional dolomite. The USGS (2007) states that the lower permeability lithologies of the Michigan Formation "are considered to be a confining unit that separates the Parma-Bayport aquifer from the underlying Marshall aquifer. The Michigan Formation is approximately 50 to over 400 ft thick in the State (Westjohn and Weaver, 1996b). The Marshall Sandstone occurs below the Michigan Formation, and only subcrops in far northwestern portions of Wexford County. The Upper Marshall is a quartzarenite to sublitharenite called the "Napoleon Sandstone Member", which is separated from lower sandstones of the Marshall by a shale, siltstone, and/or carbonate layer (USGS, 2007). The lower Marshall sandstones include two units, and the USGS states that "The Marshall aquifer ranges in thickness from 75 to greater than 200 ft within the State (Westjohn and Weaver, 1998)". It is very important to note that while the Marshall Sandstone contains fresh and saline water in northwestern portions of the state, it rapidly becomes brine (>100,000 ppm) in southeastern portions of Wexford County where it does not subcrop and occurs below the Michigan Formation (Westjohn and Weaver, 1996b). It is not projected to be a USDW in the vicinity of the landfill.

The Coldwater Shale subcrops in extreme northwestern portions of the County and consists primarily of shale with interbeds or lenses of sandstone, siltstone, and dolomite (USGS, 2007). The Coldwater Shale is relatively impermeable and is considered a confining unit in most of Michigan (Westjohn and Weaver, 1996b).

Hydrogeology of the Wexford County Landfill Area

The Glacial Drift below the Wexford County Landfill is composed of three distinct hydrogeologic units (CTI and Associates, 2008, Golder Associates, 2012): an upper sand/gravel aquifer, middle laterally extensive clay aquitard, and lower sand/gravel aquifer. The majority of domestic water wells within the area are completed in the lower sand/gravel aquifer. Figures D-2a and D-2b are local cross sections illustrating the Upper Sand/Gravel Aquifer, Middle Clay Aquitard, and Lower Sand/Gravel Aquifer.

The Upper Sand/Gravel Unit contains lenses of silt/clay and gravel of limited lateral extent; it can be over 200 feet thick in the Wexford County Landfill area. The unit is present at water table conditions (unconfined), with depth to water varying from approximately 86 to 233 feet below ground surface. Groundwater flow in the unit is to the north-northwest at approximately 212-255 feet per year (Figure D-3). Mean hydraulic conductivity is 2.68×10^{-2} cm/sec with a downward hydraulic flow gradient. Flow is toward Manton Creek and the Manistee River; Manton Creek is approximately 3 miles from the facility and the Manistee River is approximately 6 miles north (CTI and Associates, 2008).

The middle Clay Aquitard is approximately 4-30 feet thick, and serves as a laterally extensive confining unit above the lower Sand/Gravel aquifer. The unit exhibits a hydraulic conductivity ranging from 1.03×10^{-8} cm/sect to 9.85×10^{-8} cm/sec (CTI and Associates, 2008, Golder Associates, 2012).

The Lower Sand/Gravel Unit contains "non-uniform" sands with occasional fine or coarse grained lenses. The lower unit in the Wexford Area is 133-190 feet thick, and is floored by a clay sequence still within the Glacial Drift. Groundwater flow in the Lower Sand/Gravel Aquifer is to the north at a rate of approximate 413 to 496 feet per year, and the mean hydraulic conductivity is 4.61×10^{-2} cm/sec. Note that there is an additional 300 or more feet of Glacial Drift material below the clay sequence at the base of the Lower Sand/Gravel Unit based on the local Glacial Drift isopach map (Figure D-4), but lower intervals were not identified or described in available documentations. (CTI and Associates, 2008, Golder Associates, 2012).

The Glacial Drift below the Wexford County Landfill area ranges in thickness from about 500 to over 900 feet (Figure D-4); and is estimated to be approximately 700-800 feet thick in the vicinity of the Wexford County Landfill. Bedrock in the Wexford County Landfill area is either the Michigan Formation composed of limestone, anyhydrite, and shale, or the Saginaw/Parma/Bayport unit. Figure D-5 is a bedrock geology map of the Wexford County Landfill area showing the subcrop units below Glacial Drift; this map was developed based on local geologic descriptions from driller's logs which lacked detail in some instances. The Saginaw/Parma/Bayport is considered a single unit due to the variability in bedrock description.

While no water wells are completed in the Saginaw within the Wexford County Landfill area and the maximum depth of wells in Glacial Drift is approximately 400-500 feet in the general area, WWT has conservatively chosen to use the base of the Saginaw/Parma/Bayport (equivalent to the top of the Michigan Formation) as the base of the lowermost USDW for the purpose of well design. This is because it is possible, according to Westjohn and Weaver (1996b) that the Saginaw/Parma/Bayport may contain groundwater water exhibiting TDS<10,000 ppm if present immediately below the Glacial Drift. Figure D-6 is a structure contour map constructed at the top of the Michigan Formation/base of the USDW, demonstrating lateral continuity of the USDW. Figure D-7 is an isopach of the USDW, equivalent to the depth from surface datum to the top of the Michigan Formation. The Marshall Sandstone and low permeability Coldwater Shale, Sunbury Shale, Ellsworth Shale, Antrim Shale occur below the Michigan Formation, and exhibit water quality in excess of 10,000 ppm in the Wexford County Landfill area (See Table D-1 and Westjohn and Weaver, 1996a,b).

As indicated above, domestic water wells in the Wexford area are completed in the overlying Glacial Drift, the thickness of which varies locally from 500 to over 900 feet (Figure D-4). Water supply wells for the nearby cities Cadillac and Menton are also completed in glacial drift. All deep oil and gas wells are required to be cased through the glacial drift, showing the ubiquitous recognition of the interval as the area USDW. Wexford County typically obtains water supplies from groundwater sources. The USGS (2007) states "According to the February 2005 Wellogic database, approximately 98 percent of the wells in Wexford County are completed in the glacial deposits, and less than 1 percent in the bedrock units. There is insufficient information to make this distinction for 2 percent of the wells in the county". Examination of the same database in 2015 for T22N R9w Sections 1-12 and T23N R9w Sections 25-36 shows there to be a total of 154 wells in the 24 section area examined, none of which are completed in bedrock. The Wellogic database (2015) therefore shows that all water wells in the Wexford County Landfill area presented in this database are completed in the glacial drift sediments at depths ranging from less than 45 to over 440 feet. Table C-3 presents publicly available well information for wells within approximately one (1) mile of the Wexford County Landfill.

Justification of USDW Assignment

Westjohn and Weaver (1996a,b) evaluated the saline/fresh water interval in the central portion of the Michigan Basin, and the outer limits of their study area included Wexford County. Figures D-8a, D-8b and D-8c present regional identification of freshwater boundaries within the Saginaw, "Parma-Bayport" and Marshall formations; the Michigan Formation shown in Figure D-1 between the Parma-Bayport and Marshall was not addressed in Westjohn and Weaver primarily because the authors considered the Michigan Formation to be a confining zone. Data in Figures D-8a-8c suggest that the Saginaw sandstones, where they immediately underlie the glacial drift, may exhibit water quality less than 10,000 ppm TDS in the Wexford area. Similarly, Westjohn and Weaver indicated that the "Parma-Bayport" exhibited TDS less than 10,000 ppm but this formation is not clearly identified in all well logs in the Wexford area. The Michigan Formation was not addressed by Westjohn and Weaver in terms of water quality, but geologically this formation is composed of interbedded carbonates, anhydrites, and sandstones, which would likely increase the TDS concentration of any groundwater therein. Also, the Michigan Formation is identified as a confining zone by Westjohn and Weaver. Figure D-8c indicates that the Marshall sandstone immediately below the Michigan Formation is saline (greater than 10,000 ppm TDS) in the Wexford area. This is verified the USGS produced water database which identified three wells with water quality data in Wexford County as shown in Table D-1.

Table D-1
Water Quality Data, Wells in Wexford County (USGS, 2015)

IDUSGS	COUNTY	WELLTYPE	TOWNSHIP	RANGE	SECTION	FORMATION	Depth to top of Sampled Interval	SPGRAV	TDS (ppm)
17336	WEXFORD	CONVENTIONAL HYDROCARBON	N 23	W 11	26	TRAVERSE	2800	1.191	335,215
17358	WEXFORD	CONVENTIONAL HYDROCARBON	N 22	W 9	28	MICHIGAN MARSHALL	1200	1.044	67,037
17359	WEXFORD	CONVENTIONAL HYDROCARBON	N 22	W 9	22	DUNDEE	3195	1.195	339,608

Local driller's logs were examined to define bedrock in the Wexford area (Figure D-6). Driller's logs typically indicate that either the Saginaw or Michigan Formation underlies glacial drift in the Wexford County Landfill area, although the presence of the Parma or Bayport is inconsistently mentioned. In general, the Saginaw occurs to the east of the facility, and the Michigan Formation to the west (i.e. subcrop below glacial material). Based on available information in the public record, placement of the lowermost USDW at the base of the Saginaw/Parma/Bayport interval which is equivalent to the top of the Michigan Formation, is supported by local and regional water quality data.

In summary, no local data indicates that the Marshall Sandstone is a USDW. To the contrary, data suggests fluid quality above 10,000 mg/l. During well installation, if a permeable Marshall Sandstone is present, it will be subjected to log evaluation, and if calculated fluid quality is less than 15,000 ppm, fluid sampling will be conducted.

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Westjohn, D.B. and T.L. Weaver, 1996b, Configuration of Freshwater/Saline-Water Interface and Geologic Controls on Distribution of Freshwater in a Regional Aquifer System, Central Lower Peninsula of Michigan, USGS Water-Resources Investigation Report 94-4242

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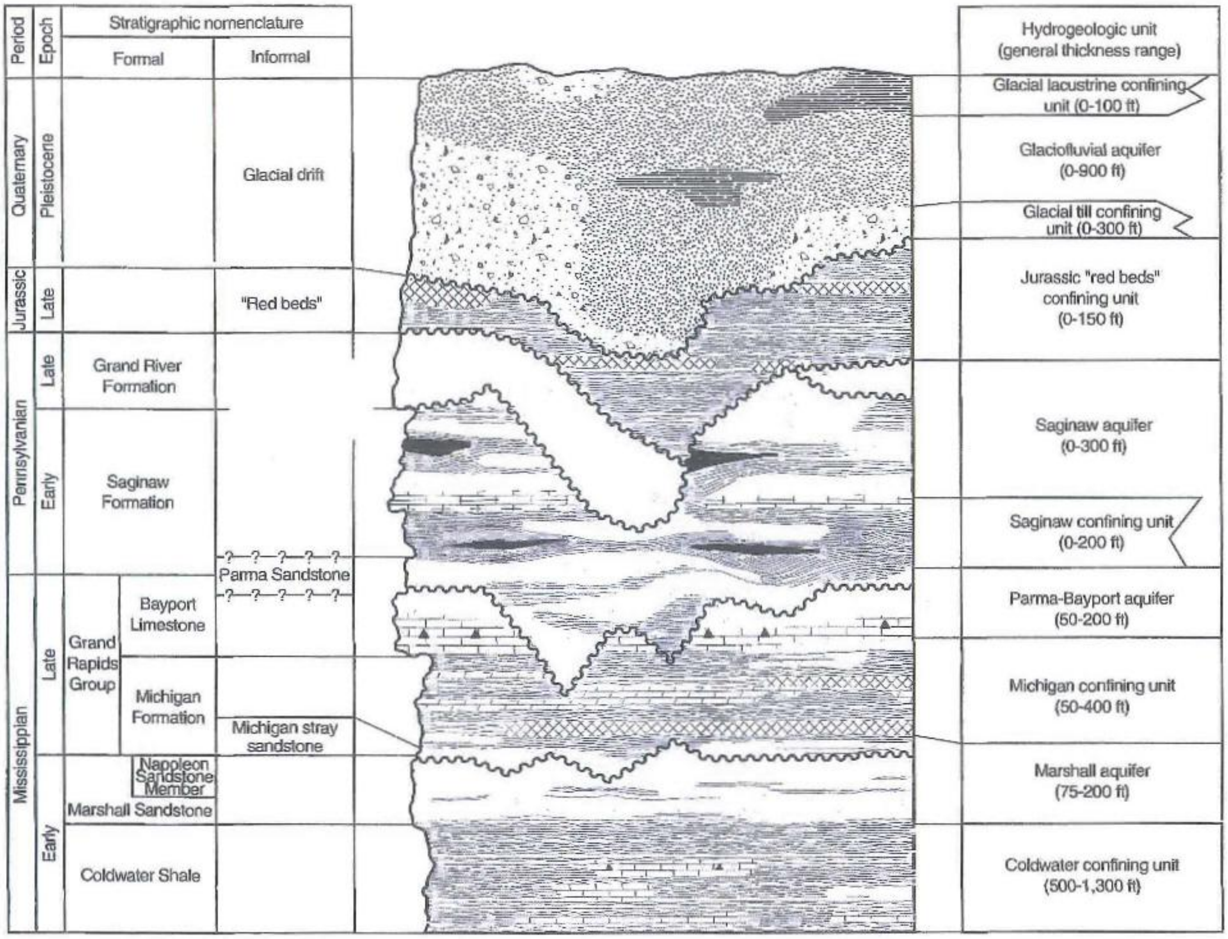

EXPLANATION

- GLACIAL LACUSTRINE SEDIMENTS
- GLACIOFLUVIAL SAND AND GRAVEL
- GLACIAL TILL
- SHALE
- SANDY OR SILTY SHALE
- SANDSTONE
- ARGILLACEOUS OR SHALY SANDSTONE
- LIMESTONE
- ARGILLACEOUS OR SHALY LIMESTONE
- CHERTY LIMESTONE
- DOLOMITE (Same variations as limestone)
- COAL BEDS
- ANHYDRITE OR GYPSUM
- EROSIONAL SURFACE

Modified from: Michigan Geological Survey, 1964

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Figure D-1a
USDW Hydrostratigraphic Column

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: May 2015	
WWTEPAPA_Fig_D-01a.ai	By: JLM	Checked: CW

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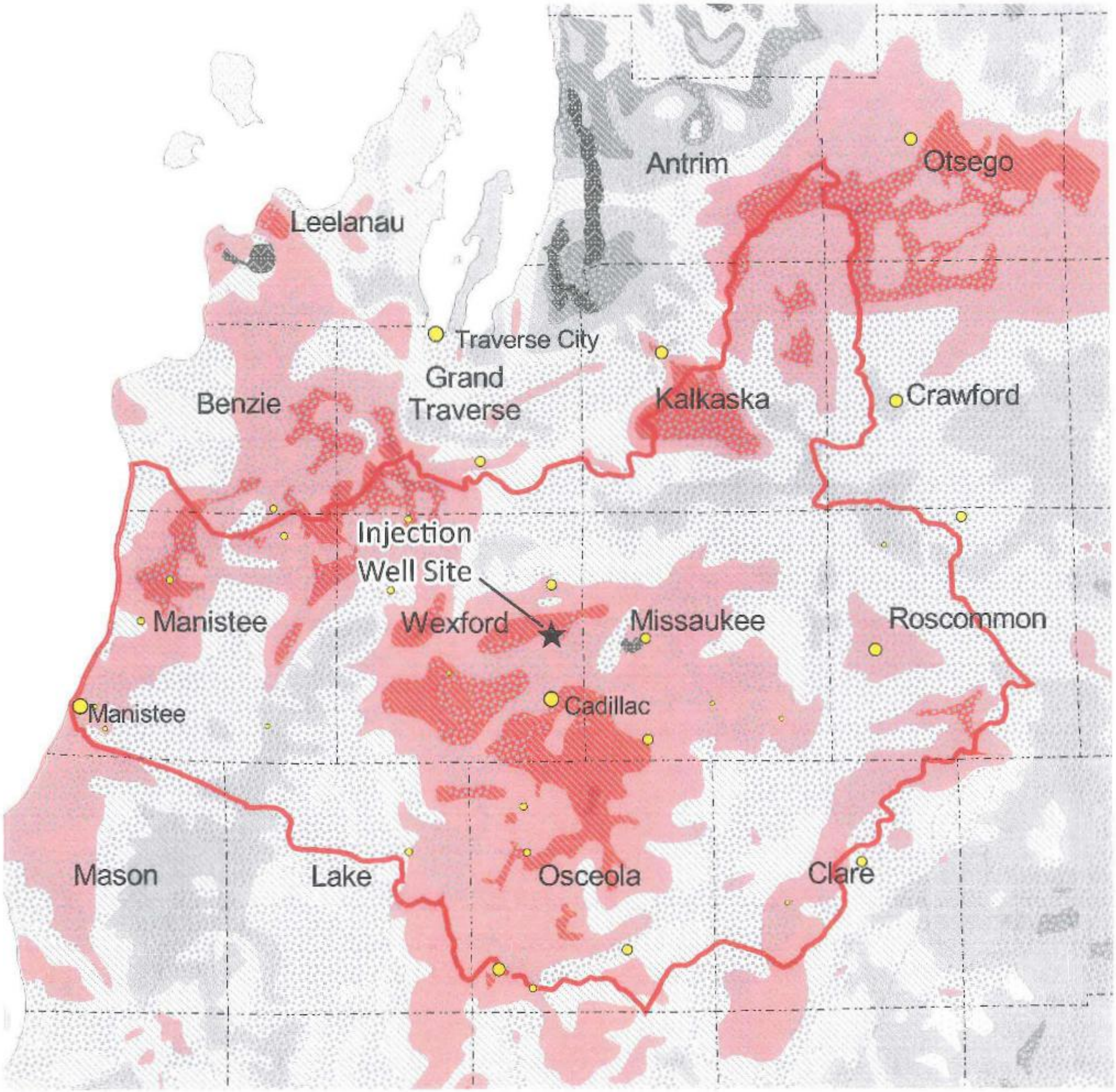
www.petrotek.com



Sollar and Packard (1998)

Cities (by population)
- 0
- 0 - 665
- 665 - 1841
- 1841 - 6128
- 6128 - 732256

County Boundaries
- County
- Lake
- Studybound.shp

Surficial Geology
- coarse stratified sediemts
- fine stratified sediments
- till
- patchy Quaternary sediments
- bdrck/non-glacial sediments
- organic-rich sediments
- water with no geologic data

Drift Thickness (in feet)
- No Data
- 100-200
- 200-400
- 400-600
- 600-800
- 800-1000
- 1000-1200

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Figure D-1b
Glacial Drift Map of Wexford and Surrounding Counties

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_D-01b.ai	By: JLM	Checked: CW

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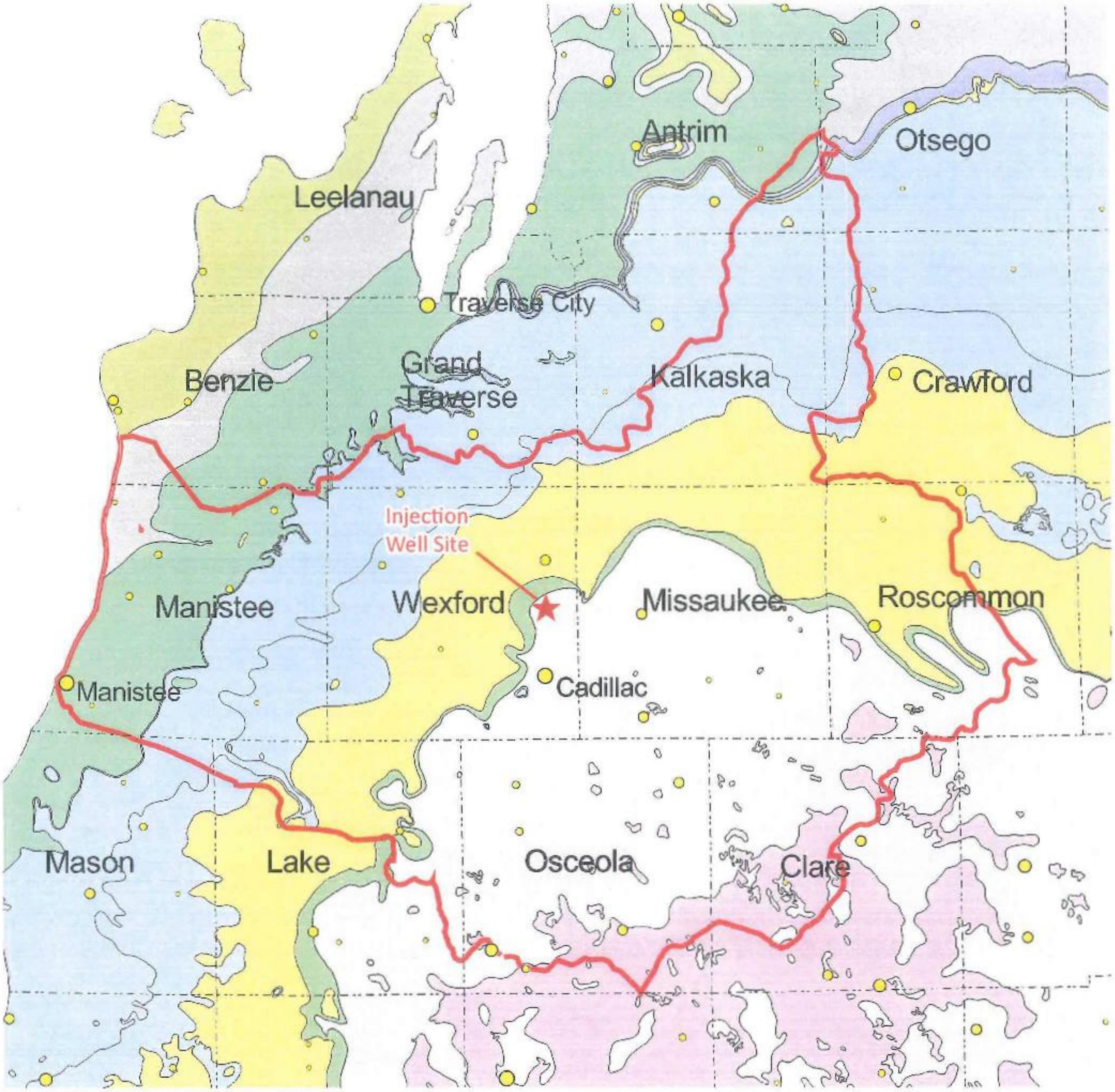

Michigan Department of Environmental Quality (1987)

Cities by Population
- 0
- 0 - 665
- 665 - 1841
- 1841 - 6128
- 6128 - 7322564

Stco24
- County
- Lake
- Studybound.shp

Bedrock Geology
- Antrim Shale
- Bayport Limestone
- Berea Sandstone
- Berea Sandstone & Bedford Shale
- Coldwater Shale
- Ellsworth Shale
- Marshall Sandstone
- Michigan Formation
- Red Beds
- Saginaw Formation
- Sunbury Shale
- Traverse Group

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Figure D-1c
Geologic Map of Wexford and Surrounding Counties

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016	
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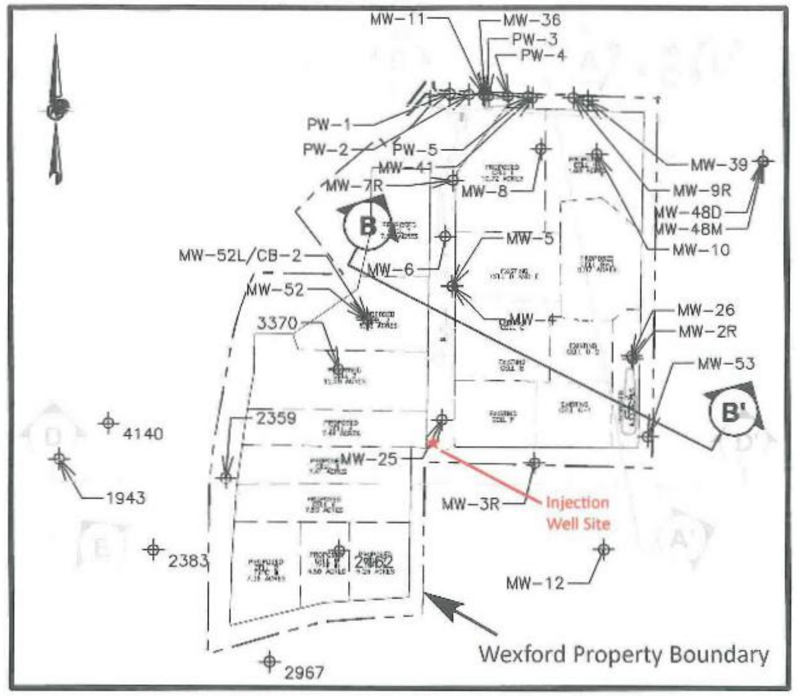

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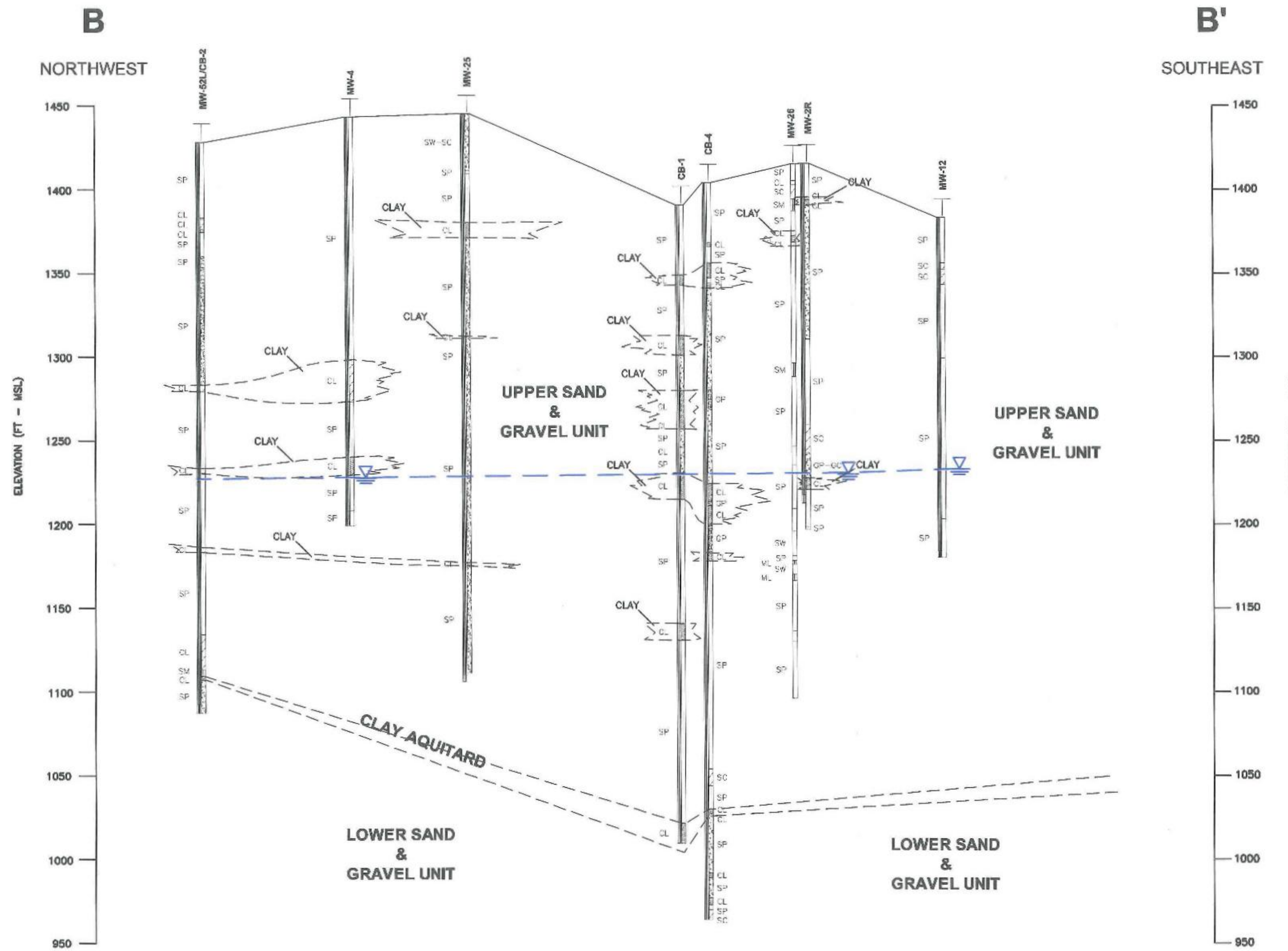

LEGEND

GROUNDWATER LEVEL

GROUNDWATER ELEVATION

NOTE

GEOLOGIC PROFILE INTERPRETATION IS BASED ON A REVIEW OF SOIL BORING LOGS, WATER WELL RECORDS AND PREVIOUS HYDROGEOLOGIC REPORTS.

400 0 400

SCALE 1" = 400' FEET

HORIZONTAL SCALE: 5x EXAGGERATION

From: Golder Associates, 2012

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Figure D-2a

USDW Cross Section B-B'

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 3/2017
WWTEPAPA_Fig_D-02a.ai	By: JLM Checked: CW

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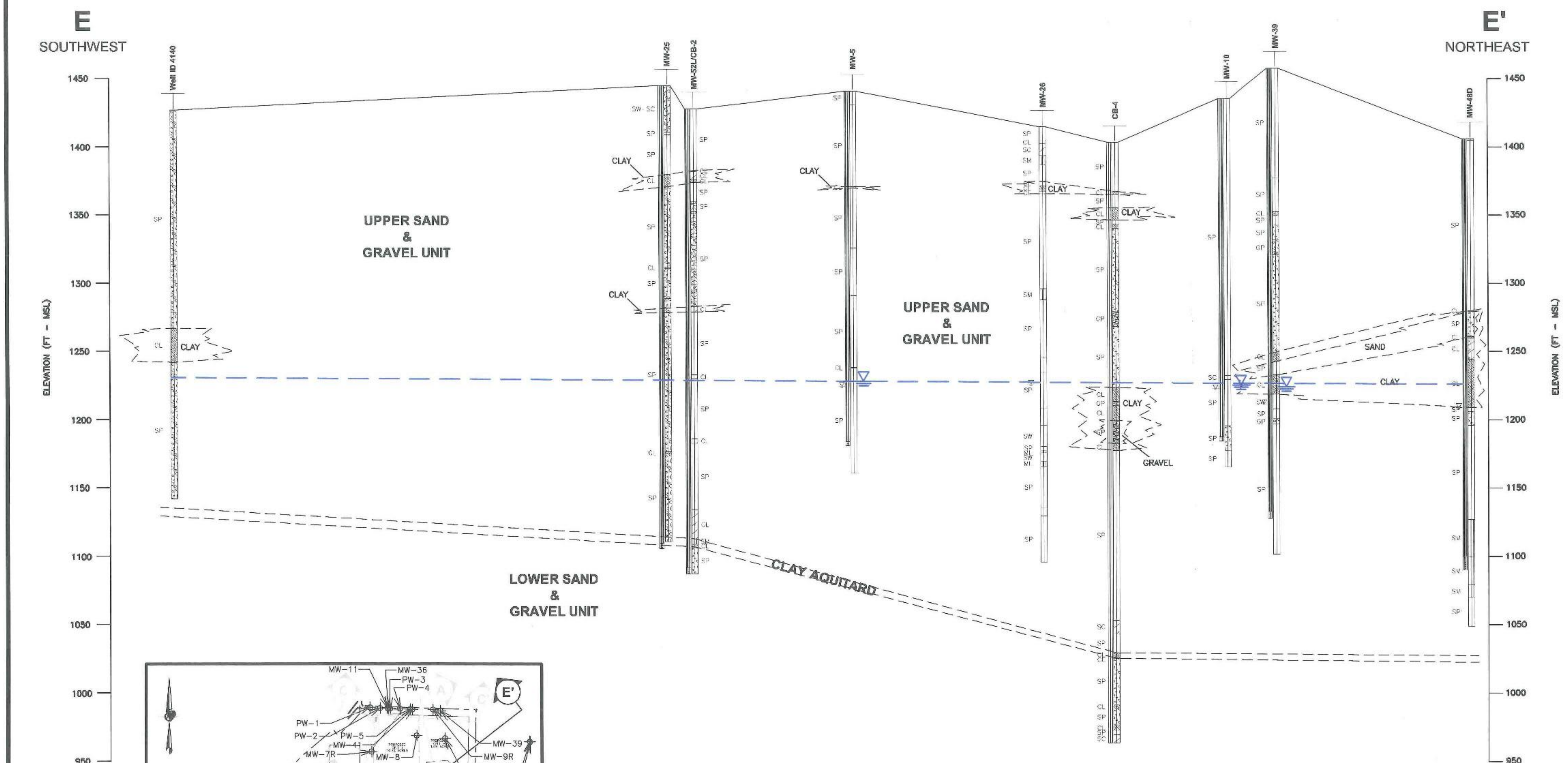
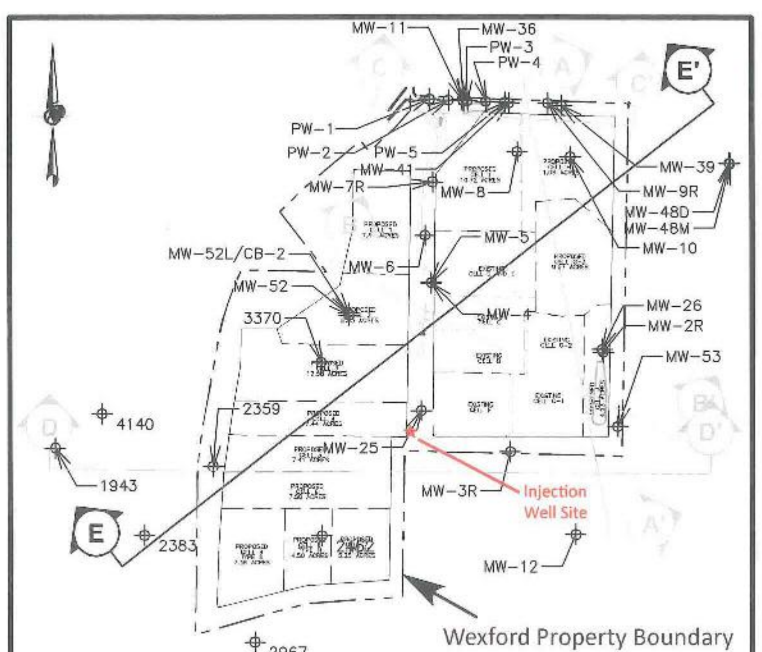


MAP KEY



LEGEND

GROUNDWATER LEVEL

GROUNDWATER ELEVATION

NOTE

GEOLOGIC PROFILE INTERPRETATION IS BASED ON A REVIEW OF SOIL BORING LOGS, WATER WELL RECORDS AND PREVIOUS HYDROGEOLOGIC REPORTS.

From: Golder Associates, 2012

400 0 400

SCALE 1" = 400' FEET

HORIZONTAL SCALE: 5x EXAGGERATION

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Figure D-2b

USDW Cross Section E-E'

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 3/2017
WWTEPAPA_Fig_D-02b.ai	By: JLM / Checked: CW

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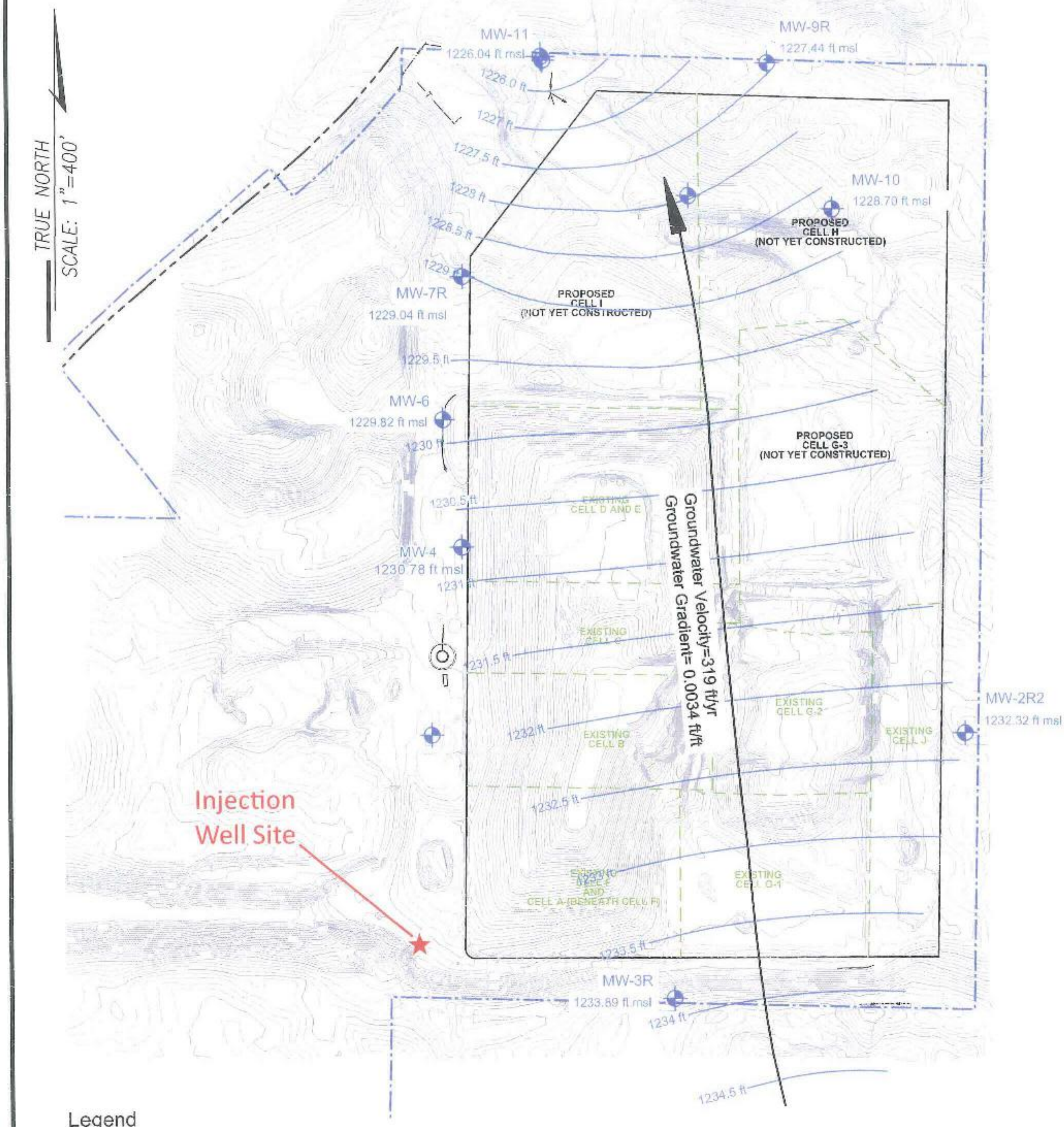

Legend

- Property Boundary
- Solid Waste Boundary
- Cell Boundary
- Monitoring Well Location
- 1232.52 Groundwater Elevation
- Groundwater Contour
- Groundwater Flow Direction

1235 ft

MW-12
1235.40 ft msl

NOTE: ONLY WELLS USED TO GENERATE GROUNDWATER CONTOURS WERE IDENTIFIED ON FIGURE 2.
BASEMAP: AERIAL TOPO DONE BY ADVANCED MAPPING TECHNOLOGIES, DATE 4-27-08

400' 0 400' 800'

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Figure D-3
Potentiometric Surface Map
Upper Sand/Gravel Unit

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016
WWEPA	By: JLM Checked: CW

TPA_Fig_D-03.ai

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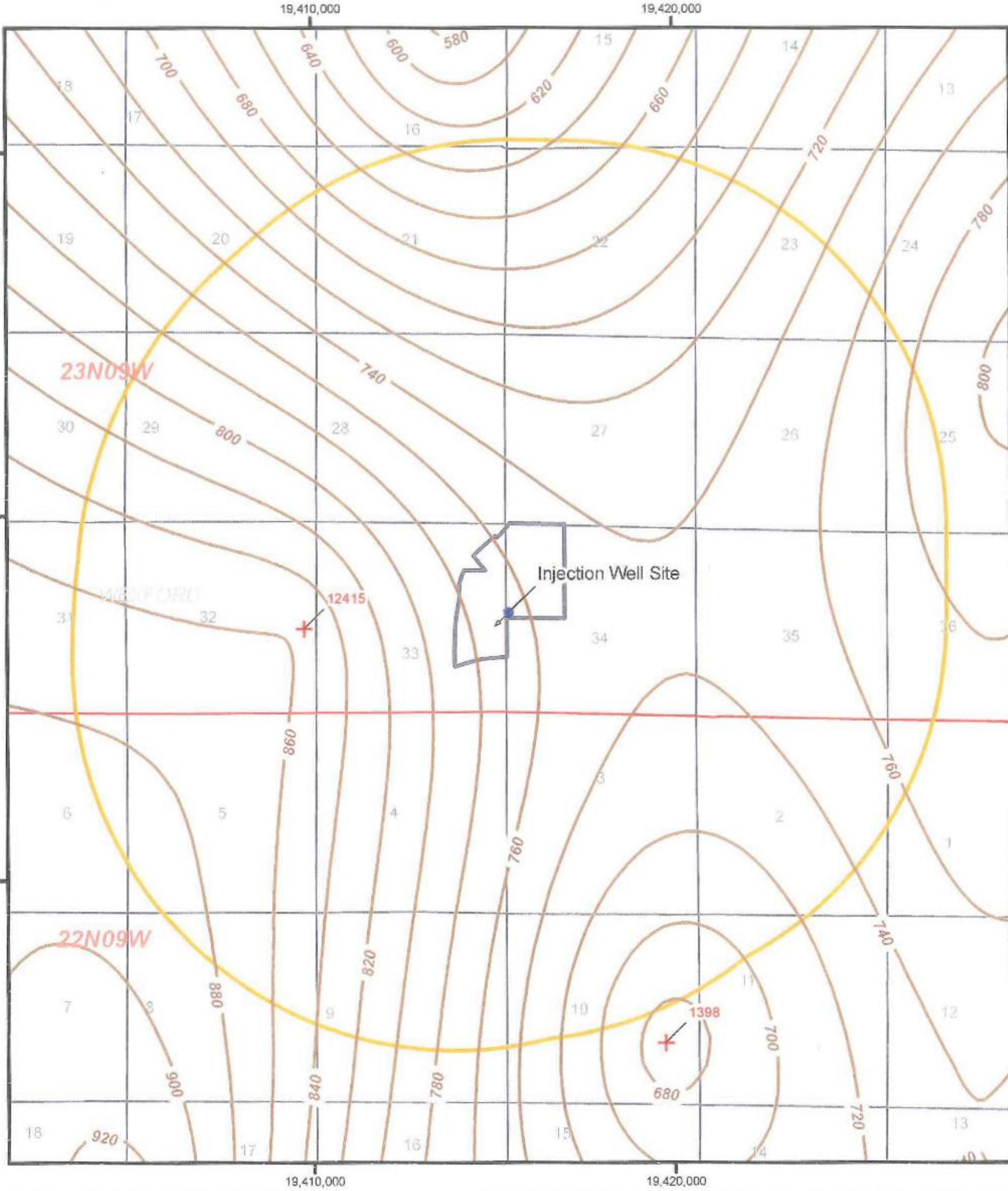

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Isopach - Glacial Drift Contours - 20ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

N

0 2,000 4,000 6,000 Feet

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Figure D-4
Isopach of Glacial Drift,
Wexford Area

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_D-04.mxd	By: JLM	Checked: CW

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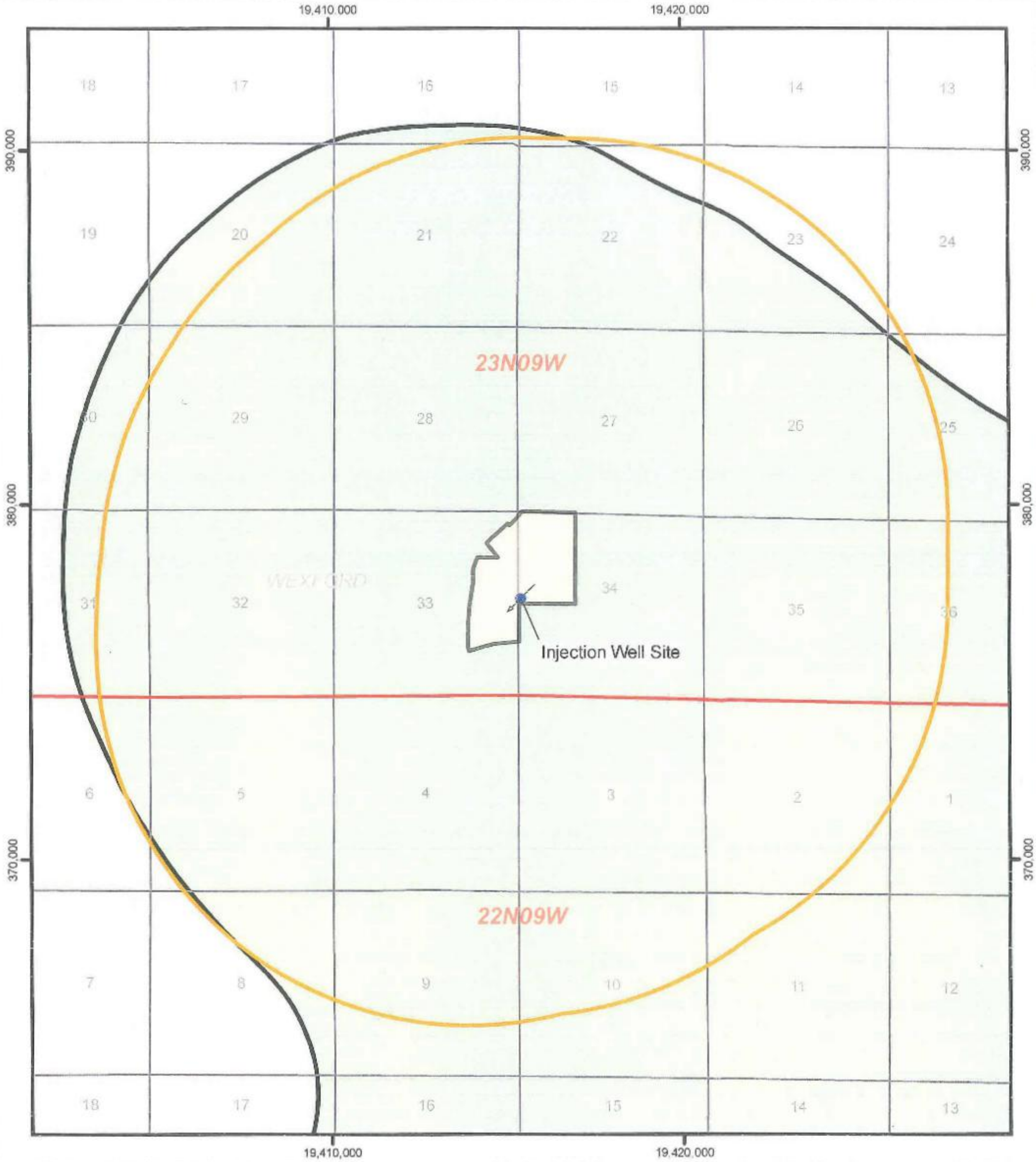

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Wexford Property Boundary
- 2 Mile AOR
- Michigan Formation
- Saginaw / Batpoint / Parma Formation

N

0 2,000 4,000 6,000 Feet

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Figure D-5
Bedrock Geology Map, Wexford Area

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_D-05.mxd	By: JLM / Checked: CW

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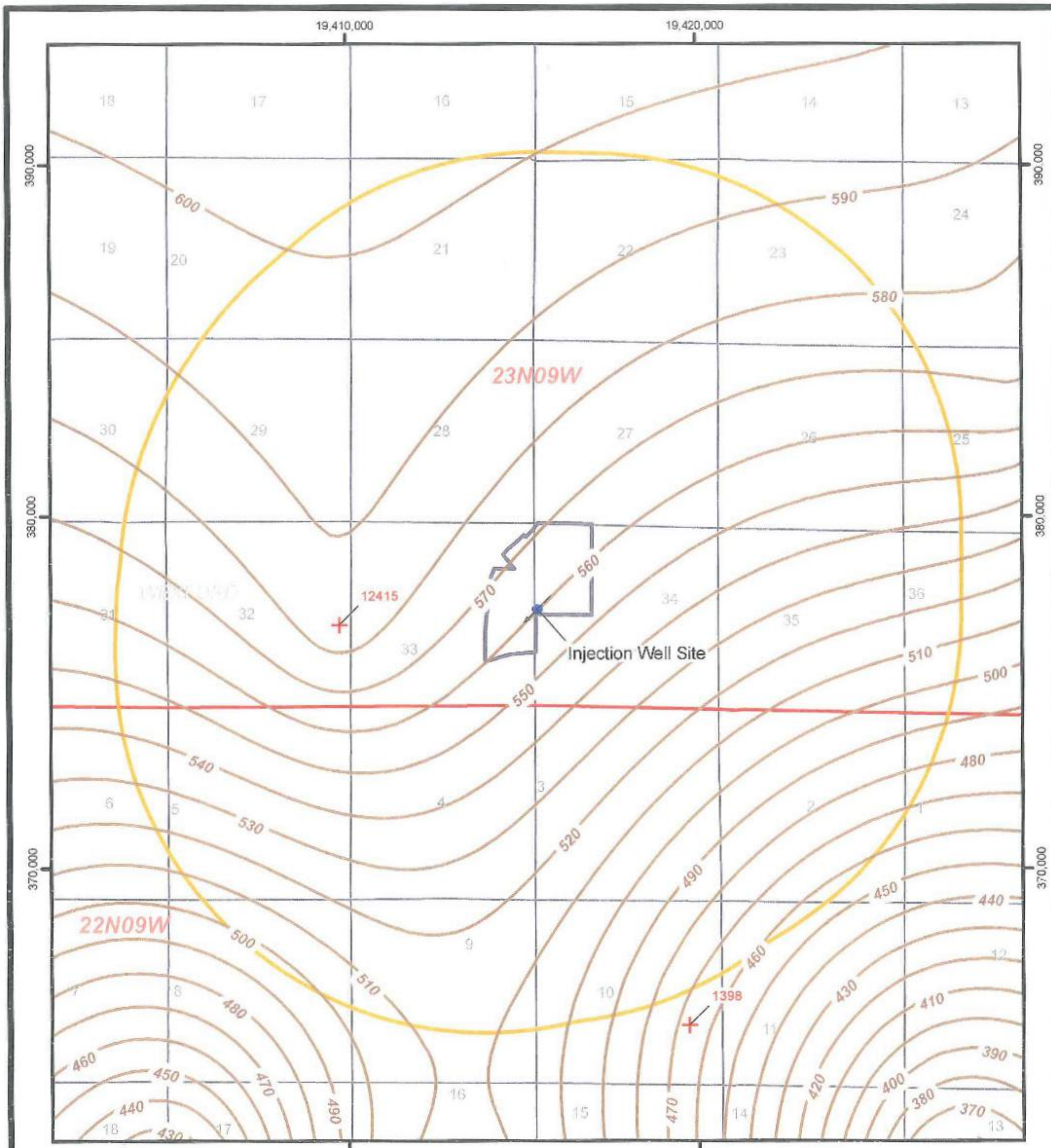

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Structure - USDW Contours - 10ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

0 2,000 4,000 6,000 Feet

Wexford Water Technologies, LLC

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Figure D-6
Structure Contour Map, Base of USDW/Top of Michigan Formation

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_D-06.mxd	By: JLM	Checked: CW

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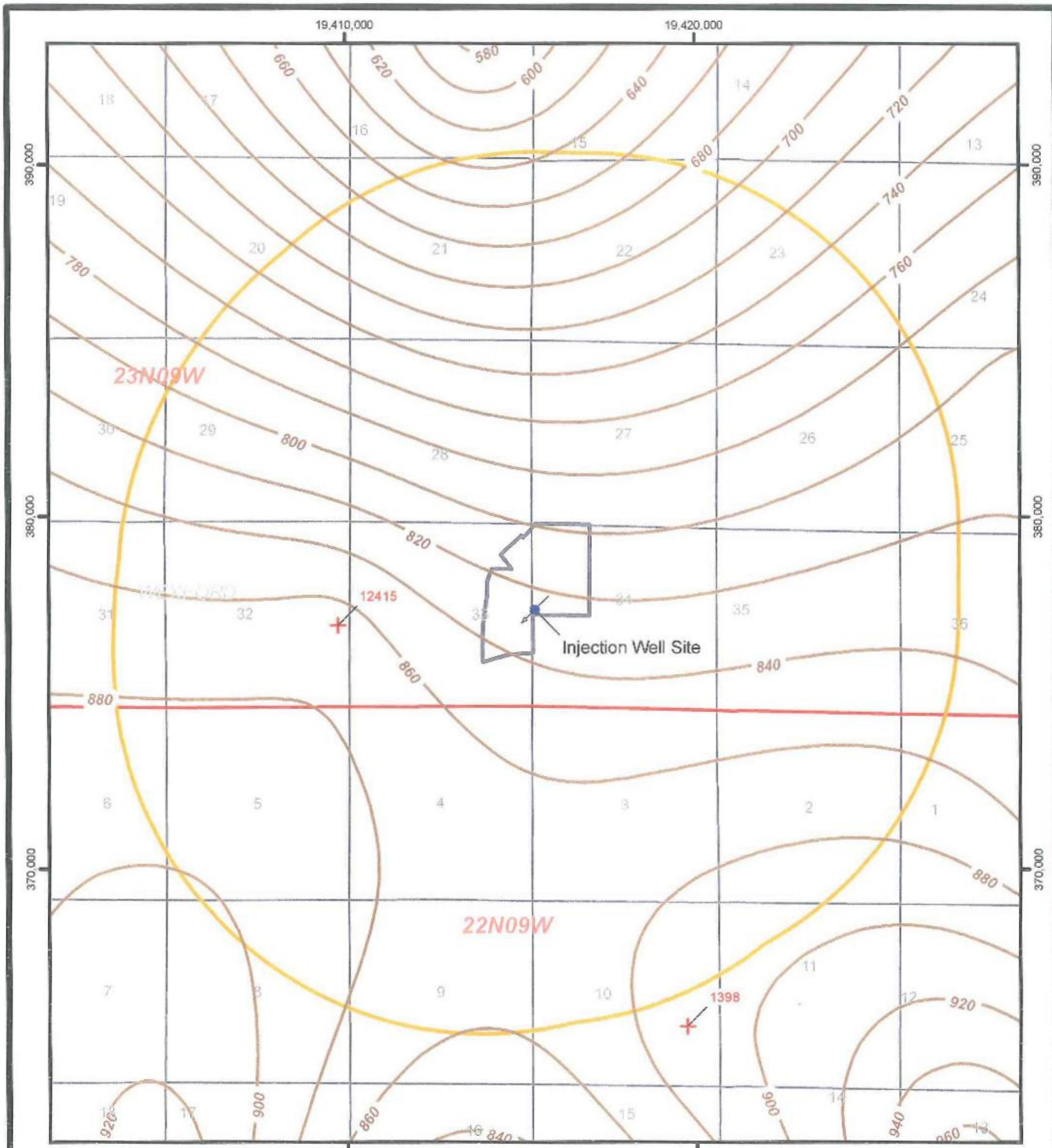

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Isopach - USDW Contours - 20ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

0 2,000 4,000 6,000 Feet

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Figure D-7
Isopach of the USDW
Wexford Area

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_D-07.mxd	By: JLM / Checked: CW

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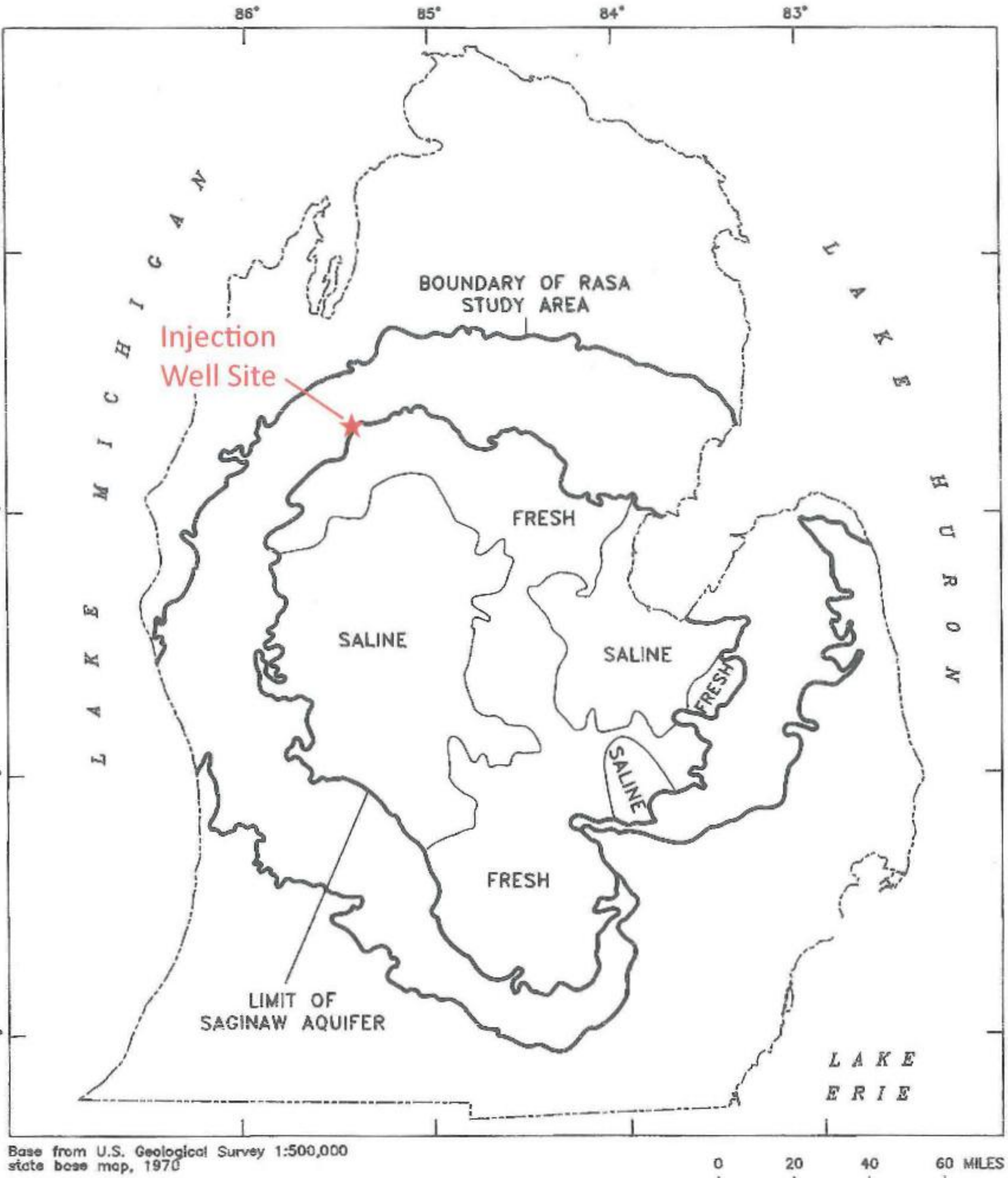

EXPLANATION

FRESH--1,000 mg/L (milligrams per liter) or less dissolved solids

SALINE--Greater than 1,000 and less than 100,000 mg/L dissolved solids

From: Water-Resources Investigations Report 94-4242, 1996

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Figure D-8a
Distribution of Freshwater, Saline Water and Brine, Saginaw Sandstone

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_D-08a.ai	By: JLM · Checked: CW

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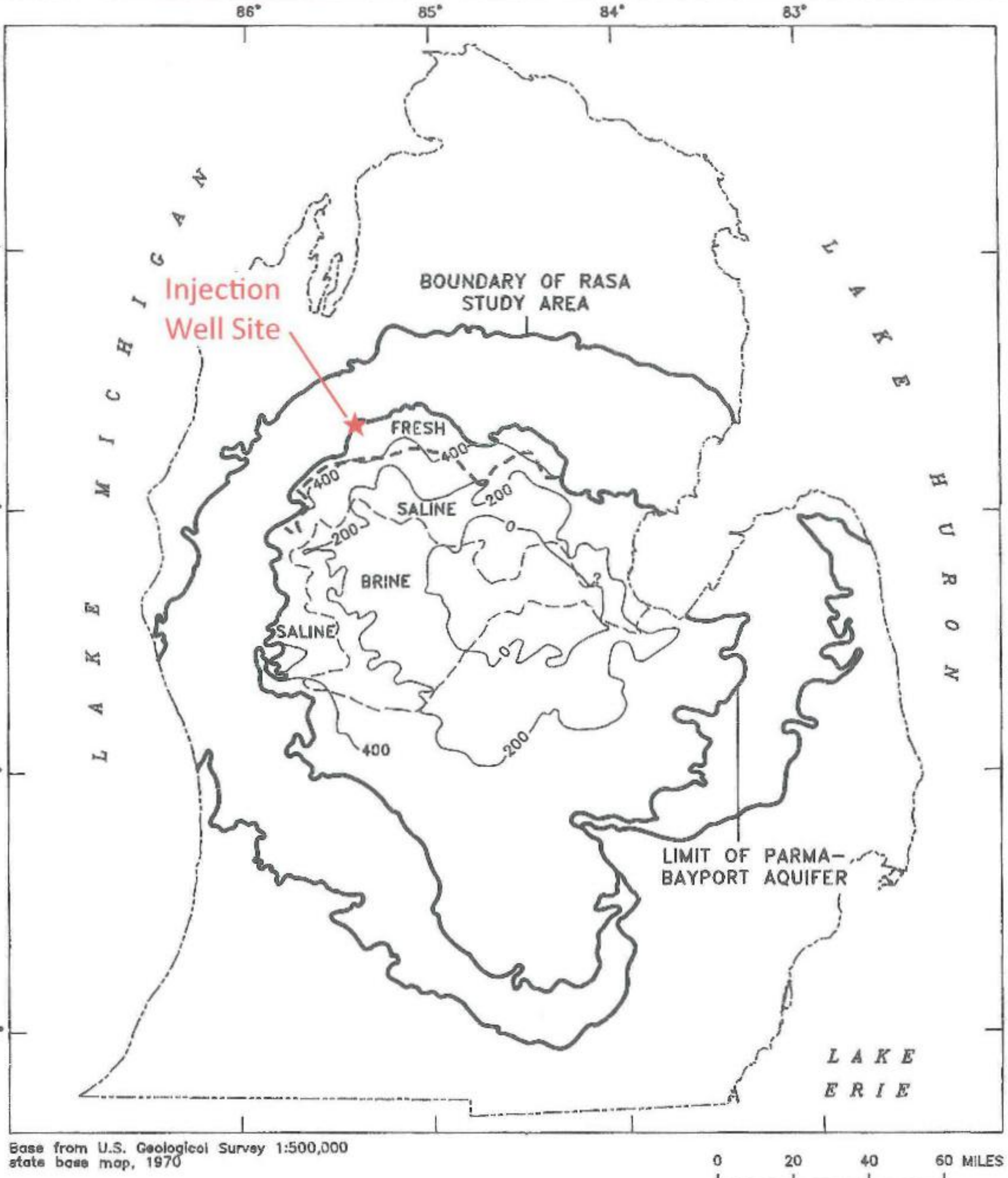

EXPLANATION

—200— STRUCTURE CONTOUR--Shows altitude of top of Marshall aquifer. Absent where data are insufficient. Contour interval 200 feet. Datum is sea level

- - - - - FRESHWATER/SALINE WATER INTERFACE--Absent where data are insufficient

- - - - - SALINE WATER/BRINE INTERFACE--Queried where approximate

FRESH--1,000 mg/L (milligrams per liter) or less dissolved solids

SALINE--Greater than 1,000 and less than 100,000 mg/L dissolved solids

BRINE--100,000 mg/L or more dissolved solids

From: Water-Resources Investigations Report 94-4242, 1996

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Figure D-8b
Distribution of Freshwater, Saline Water and Brine, Perma-Bayport Sandstone

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_B.7-07b.ai	By: JLM	Checked: CW

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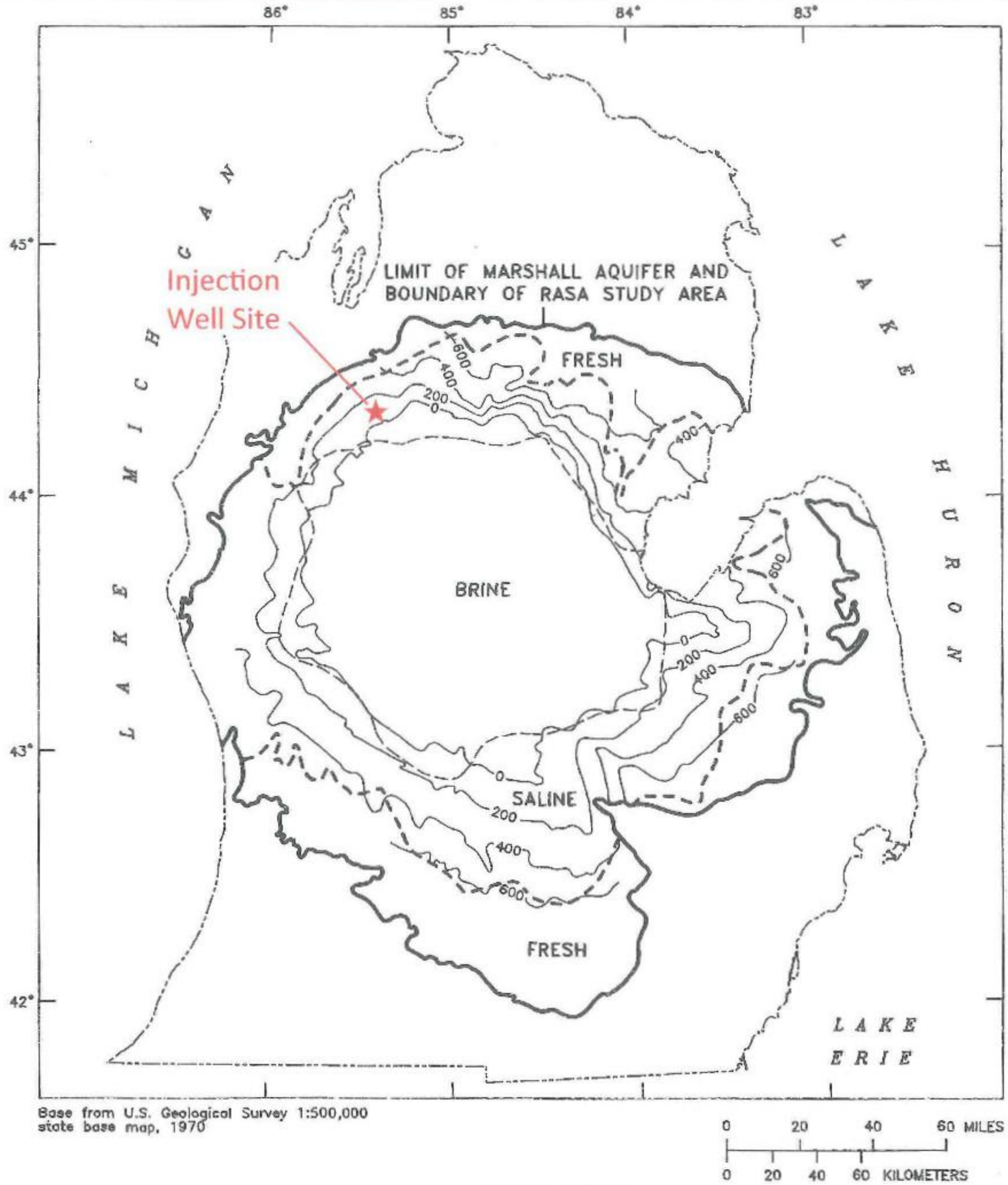

EXPLANATION

—200— STRUCTURE CONTOUR—Shows altitude of top of Marshall aquifer. Absent where data are insufficient. Contour interval 200 feet. Datum is sea level

- - - - - FRESHWATER/SALINE WATER INTERFACE—Absent where data are insufficient

— — — SALINE WATER/BRINE INTERFACE

FRESH—1,000 mg/L (milligrams per liter) or less dissolved solids

SALINE—Greater than 1,000 and less than 100,000 mg/L dissolved solids

BRINE—100,000 mg/L or more dissolved solids

From: Water-Resources Investigations Report 94-4242, 1996

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Figure D-8c
Distribution of Freshwater, Saline Water and Brine, Marshall Sandstone

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_D-08c.ai	By: JLM	Checked: CW

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2.E NAME AND DEPTH OF USDWs

For Class II Wells (Not Applicable to this Application)

2.F MAPS AND CROSS SECTIONS OF GEOLOGIC STRUCTURE

Submit maps and cross sections detailing the geologic structure of the local area (including the lithology of injection and confining intervals) and generalized maps and cross sections illustrating the regional geologic setting.

Response:

The following information describes the regional and local geology of the Wexford County Landfill. Figures provided herein include regional and local cross sections, geologic structure maps, the stratigraphic column, and various isopach and other maps. These figures and related text address the geology of the injection zones (Dundee and Traverse, or if unsuitable the Amherstburg/Sylvania/Bois Blanc/Bass Islands) as well as the confining intervals (Antrim, Ellsworth Sunbury, Coldwater, and Bell Shales, and Detroit River Formation).

If the Traverse is determined to be the optimal injection target, the Confining Zone will be the Coldwater-Antrim interval. If the Traverse it not optimal and injection is to take place only into the Dundee, then the Bell Shale is an additional confining interval. Similarly, if neither the Dundee nor Traverse is an optimal injection interval, then WWT may drill deeper through the Detroit River Salts/Lucas Formation to encounter the Amherstburg, Sylvania, Bois Blanc, and/or Bass Islands, terminating drilling when an optimum injection interval is encountered. If the injection zone is one or more of these deeper intervals, then the Detroit River Salts, Bell Shale, and Coldwater-Antrim intervals will all serve as confining zones.

2.F.1 Regional Geology

2.F.1.1 Regional Stratigraphy

Geologic strata in the Northwest region of lower Michigan (Michigan Basin) consists of up to 10,000 feet of sandstones, shales, limestones, conglomerates and clays deposited above crystalline basement rocks. Figure F-1 presents a stratigraphic column of the greater Michigan Basin that identifies key stratigraphic sequences.

2.F.1.1.1 Precambrian-Cambrian Rock Units

The thick sedimentary column in the Michigan Basin is underlain by Precambrian-aged crystalline granites and metamorphic rocks (Figure F-1). According to the Midwest Regional Carbon Sequestration Partnership (MRCSP) website (2015) and Milstein (1989), the top of the Precambrian below Wexford occurs approximately 10,500 feet below ground surface near the Wexford County Landfill. Above this basement rock, coarse-grained "Pre-Mt. Simon" sandstones may have been unconformably deposited. These "pre-Mt. Simon" units can be of varying thickness and, where present, are topped by the pervasive Mt. Simon sandstone. The Mt. Simon is a basal sandstone to conglomerate below the Munsing Group that occurs either directly atop the Precambrian basement or upon the "pre-Mt. Simon" sandstones. The Mt. Simon is described as subrounded to rounded quartz-feldspathic sandstones that can be very coarse grained, pink-red at the base, and lighter in color upsection; it is projected to be about 600 to over 800 feet thick below Wexford County. The Mt. Simon exhibits a gradational contact with the overlying Eau Claire Formation (WMU, 1981). Figure F-2a is a structure contour map at the top of the Precambrian, and Figure F-2b is an isopach of the Mt. Simon Formation. Figure F-2c is an isopach of the Eau Claire formation.

2.F.1.1.2 Ordovician-Silurian Rock Units

Ordovician and Silurian-aged sediments composed predominantly of carbonates and shales were deposited unconformably above the Cambrian sandstone-rich sequences in this northwestern portion of the Michigan Basin. Regional geologic information indicates that the basal Ordovician-age Prairie due Chien group occurs about 6,500-7,000 feet below sea level, and is approximately 1,000-1,300 feet thick in Wexford County. Data suggest that the St. Peter/Glenwood formation that occurs above the Prairie du Chien; the Prairie du Chien and overlying St. Peter sandstone were the last major sandstone sequences before deposition of the thick shales and carbonates of the general Ordovician-Silurian section. Overall, the Cambrian-middle Ordovician sequence, which includes all sediments from the Precambrian to the top of the Glenwood, is likely over 3,750 feet thick below east central Wexford County (from Milstein, 1983).

An unconformity occurs at the base of the Trenton/Black River (Figure F-1). The Trenton is described as a thick limestone that is locally dolomitized, deposited as a platform carbonate on an open marine shelf. This is topped by thick Utica Shales, which is a distinct marker bed in the Michigan Basin. Above the Utica Shales are various limestone and dolomite sequences, including the Niagaran, which is a thick carbonate reef complex that rings the northwestern and southeastern portions of the Michigan Basin. These reefs have produced significant quantities of hydrocarbons and are oil-producing to the northwest of the proposed WWT well site. The Niagaran Reef units include finer-grained basinal facies that grade laterally outward to "shelf facies" which contain hydrocarbon-bearing "pinnacle reefs"; the unit continues to thicken at the basin margin forming the bank/barrier reef units. As a result, porous Niagaran units ring portions of the margin of the basin, as evidenced by the occurrence of oil/gas fields in northwest and southeastern Michigan (WMU, 1981)

The Niagaran reefs and reef complexes grew upward through and are topped by the various evaporates and carbonate sequences of the greater Salina Group. The Salina is characterized by multiple evaporates (i.e. anhydrite and salt) and carbonates, with varying amounts of shales that were formed during multiple evaporation sequences deposited in the basin during/following the Niagaran period (WMU, 1981). The Salina could be approximately 1,800-2,500 ft thick below Wexford County, based on regional data.

The Bass Island Group occurs above the Salina, and is composed of a thick sequence of fine-grained dolomites that have anhydrite crystals with an occasional salt-rich unit. The Bass Islands is identified by WMU (1981) as a "confining unit" in this portion of Michigan, because it is relatively thick and exhibits low permeability, although this may be compromised around the margin of the basin due to secondary salt and anhydrite dissolution. The Bass Islands (Figure F-3) as a whole is about 300-350 feet thick in east central Wexford County, with the upper dolomite sequence approximate 65-75 feet thick (Harrison et al, 2009).

2.F.1.1.3 Devonian Detroit River Group

Regionally, the Bass Islands Group is capped unconformably by Garden Island and cherty Bois Blanc Formations that are composed of dolomitic sandstones and dolomites. The Detroit River Group occurs above the Bois Blanc and includes the lower sandstone Sylvania unit (where present), the carbonaceous-limestone Amherstburg Formation, and the Lucas Formation. However, only the Lucas Formation is the unit typically referred to as the "Detroit River Group" (although Figure F-1 shows that, technically, the group includes the Sylvania and Amherstburg). The Lucas Formation/Detroit River is described as "a wide variety of lithologies including sandstone, limestone, dolomite, anhydrite (or gypsum) and halite" (Landis, 1951). Specifically, the Richfield zone of the Lucas/Detroit River is a sequence of interbedded limestone, dolomite and anhydrite that is capped by the "Massive Anhydrite" Unit. The Horner sequence occurs above this formation, and is composed of salts and anhydrites, with minor carbonates. WMU (1981) indicates that these upper evaporate-rich sequences of the Detroit River exhibit very low vertical permeability. Regional data suggest that the Detroit River (Lucas Member) may be about 800-1,000 or more feet thick below Wexford County. Figures F-4, F-5, F-6, and F-7 present isopach maps of the Bois Blanc, Sylvania, Amherstburg, and Detroit River (Lucas Member), respectively.

2.F.1.1.4 Devonian Dundee Formation

The Dundee Formation occurs conformably above the Detroit River, and can be both an oil-producing zone and injection target in the Michigan Basin. It has been interpreted as a single formation composed of two members, the dolomitic Reed City (below an anhydrite unit), and overlying carbonate Rogers Member. The Dundee is a buff-brownish finely-coarsely crystalline limestone that becomes more dolomitic in western portions of the Michigan Basin. The Dundee was deposited under shallow carbonate shelf to near shore "sabkah" environments in the western portions of the Michigan Basin. In Wexford County, the Dundee is about 150-250 feet thick and is composed of limestone and dolomites, with some anhydritic components. The Dundee generally occurs about 3,800 or more feet below ground surface in eastern Wexford County. WMU (1981) indicated that "in areas where the Dundee has been dolomitized, it could be and is used as an injection formation for chemicals and brine". Figure F-8 is a regional structure contour map constructed for the Dundee Formation (elevation with respect to sea level), and Figure F-9 is a regional isopach map of the Dundee.

2.F.1.1.5 Devonian Traverse Group

The Traverse Group is composed of several individual carbonate and shale-rich sequences, deposited conformably above the Dundee. Catacosinos et. al. (1991) state that the Traverse is typically divided into three formations or units in ascending order: the Bell Shale, Traverse Limestone, and Traverse Formation, although the Traverse Limestone and Formation are also divided into a multitude of formations and members that have been identified throughout the region. The Bell Shale is the lowermost unit of the Traverse, and is a blanket shale sequence deposited atop the Dundee throughout most of the Michigan Basin. In eastern Wexford County, the Bell Shale is about 60-100 or more feet thick, and is composed of limey, fossiliferous shales and clays. Figure F-10 is a regional isopach map of the Bell Shale.

In general, the "Traverse Limestone" can be an oil producing unit that is more carbonate-rich in western portions of the basin and grades to more shale-rich units in the east. The "Traverse Formation" is described by Cataconisinos (1991) as consisting 'mostly of gray shale and intercalated limestones". The Traverse as a whole is about 600-650 feet thick (excluding the Bell Shale) below Wexford County, and is composed predominantly of carbonates and interbedded shales. Figure F-11 is a regional structure contour map constructed at the top of the Traverse Group, and Figure F-12 is a regional isopach of the Traverse Group that also shows % shale occurrence within this Group.

2.F.1.1.6 Late Devonian - Mississippian Units

Thick, shale-rich Devonian-Mississippian age sequences occur above the Traverse Group, including the Antrim Shale which is capped by the Ellsworth, Sunbury, and Coldwater Shales. The Antrim is described as an organic-rich, silica-rich interval that in some locations can be fractured at or near the outcrop for several potential reasons including fracturing of silica-rich, relatively brittle rock at depth, subsequent uplift, glacial rebound and resultant fracture opening, and/or lateral sedimentary variations that impact fracture generation. Antrim gas, where present, may be biogenic in nature. Both fractures and gas generation were influenced by the influx of fresh water at the unit outcrop or subcrop where the Antrim occurs at or near the contact with overlying glacial sediments. The Ellsworth is described as a lateral facies variation of the Antrim, although regional maps indicate that both the Antrim and Ellsworth are present below Wexford County. The Sunbury occurs above the Ellsworth (Figure F-1). Geologic maps (Michigan Department of Natural Resources, 2001) indicate that the Coldwater Shale, which occurs above the Sunbury, subcrops below glacial till in southern Grand Traverse and northwestern Wexford Counties, although the Michigan Formation and Saginaw Sandstone subcrop specifically below the Wexford County Landfill area, as discussed in Section 2.D. The Antrim-Coldwater sequence is about 1,400-1,650 feet thick below Wexford County. Figure F-13 is a regional isopach map of the Antrim Shale; Figure F-14 is a regional isopach map of the Ellsworth Shale; Figure F-15 is a regional isopach map of the Sunbury Shale, and Figure F-16 is a regional isopach map of the Coldwater Shale.

2.F.1.1.7 Glacial Till

The latest glacial cycle in North America began about 2 million years ago and ended about 12,000 years ago. As a result of these events, thick glacial sediments cover the ground surface in much of the Northern United States, and Michigan is no exception (Figure F-17). These deposits vary widely in their characteristics, but glacial sediments of Wexford County range in thickness from 201 to over 1000 feet (WMU, 1981, Figure D-4). According to the USGS (2007):

> "The glacial deposits in Wexford County consist of outwash, till, and lacustrine deposits (Stewart, 1948; Farrand and Bell, 1982). Outwash deposits are abundant in the county and are generally underlain by well-jointed clayey till. Till occurs in till plains and moraines. The Lake Border Moraine covers the largest area in Wexford County. In the southeastern portion of the county, the Valparaiso and Charlotte Moraines are present. These are part of the Lake Michigan-Saginaw Interlobate tract. The Port Huron Moraine covers a small area in the north-central portion of the county. The till within the moraines contains abundant boulders, sand, and silt near the surface (Stewart, 1948). This till is classified as coarse-textured (Farrand and Bell, 1982). Underlying the till is an older clayey till (Stewart, 1948). Sand and gravel lacustrine deposits are present on the surface in the southeastern portion of the county, near Cadillac (Farrand and Bell, 1982). Sand dunes are common on the surface of glacial features throughout the county (Stewart, 1948)."

2.F.1.2 Regional Structural Geology

The major geologic structural feature of Michigan is the Michigan Basin (Figure F-18), which is a "nearly circular, intracratonic basin 400 km in diameter and 5 km deep with only minor structural disruption" (Howell and van der Pluijm, 1999). Additionally, work by various authors identifies other structural trends within the greater Michigan Basin (from Wood and Harrison, 2002): "Regional structural trend maps of the Michigan Basin show the presence of numerous northwest-southeast oriented fold or anticlinal trends but few, if any, fault trends or traces". Many of these fold trends are asymmetric toward the north. Theories regarding the origin of these fold trends postulate the episodic reactivation of zones of basement weakness at one or more times during the Paleozoic." Maps produced by Wood and Harrison (2002) indicate that there are several northwest-southeast trending features that may be basement faults or structures that occur predominantly in the central portion of the Michigan Basin (Figure F-19). These intervals have been mapped in the Dundee, but map data to not indicate that these trends or features extend from the central portion of the basin to Wexford County.

2.F.2 Site-Specific Geology

The Wexford County Landfill occurs in east central Wexford County at T23N R9W Sections 33 and 34. Figure F-20 presents the location of deep wells an approximately 5 mile area surrounding the Wexford County Landfill facility, and shows the locations of two local cross sections (Figures F-21a and F-21b) constructed through the site. These cross sections extend to the top of the Detroit River as there are no deeper wells logs within 5 miles of the Wexford County Landfill, and include geologic descriptions rather than geophysical logs at a few locations where no geophysical logs were run. Figures F-22a, F-22b, and F-22c are regional cross sections that show the development and correlation of units below the Detroit River based on more distant data.

2.F.2.1 Local Stratigraphic Column

Table F-1, below, identifies the estimated tops of units below rig kelly bushing (RKB) at the WWT Well No. 1 location based on area-specific data for formations above the Detroit River and local and regional estimates for formation tops below the Detroit River. Tops identified in historic records may not correspond exactly with those shown on Figures F-21a and F-21b because formation top assignments were re-examined and refined, if necessary, required, based on well logs and other data. Actual formation tops at the proposed WWT Well No. 1 location will be verified during well installation.

Table F-1
Approximate Stratigraphic Tops, Depth from RKB,
WWT Well No. 1 from regional and local data

Unit	Estimated Top Depth Below Datum (RKB; feet)
Glacial Drift	0-758
Saginaw Sandstone	788 (top)
Michigan Formation	810-890
Marshall Formation	1,377
Coldwater Shale	1,563
Sunbury Shale	2,317
Ellsworth Shale	2,366
Antrim Shale	2,856
Traverse Formation	3,166
Traverse Limestone	3,216
Bell Shale	3,799
Dundee	3,855
Detroit River (including salt)	4,066
Detroit River Carbonates –Richfield Member	4,800
Amherstburg Fm	5,035
Sylvania	5,250
Bois Blanc	5,515
Bass Islands	5,715 feet

Figures F-21a and F-22b are cross sections that present the local stratigraphy below the Wexford County Landfill. The deepest wells in the area were drilled to the Detroit River. The site-specific geologic discussion focuses on the Devonian Shales (e.g. Antrim), Traverse, Bell Shale, Dundee, and Detroit River because the shallowest and most desirable injection zones are the Traverse and Dundee. However, because local data is based on wells drilled primarily in the 1930s to 1950s, it is possible the Traverse or Dundee may prove not to be optimal injection targets. If that is the case, the well may be deepened through the Detroit River salts and carbonates to intervals below this confining zone including the Amherstburg, Sylvania Sandstone, Bois Blanc, and Bass Islands. Anticipated local geology of all the potential injection and confining zones are discussed below.

2.F.2.1.1 Mississippian-Devonian Units

Mississippian units underlie the Glacial Drift and include the Saginaw Formation, Bayport Limestone, Michigan Formation with basal Marshall Sandstone, Coldwater Shale, and Sunbury Shale. Devonian shale units below the Mississippian include the Ellsworth Shale and Antrim Shale. Descriptions of each unit based on local drillers log descriptions are as follows (based on Well Permit Nos. 1398 and 39695, see Figure F-20):

- Saginaw/Parma/Bayport Interval: The Saginaw Formation is described locally as a light brown to white sandstone with interbedded gray shale. The Saginaw is generally composed of interbedded sandstones, shales, limestone, and coal. The sandstone beds vary considerably in thickness and thin or pinch out in relatively short distances. The Parma Sandstone occurs at the base of the Saginaw and is described as a medium to coarse grained sandstone that is generally less than 100 feet thick but may be as much as 150 feet in some areas of the State. The unit appears to be lenticular in shape and cannot easily be distinguished as a separate entity in the subsurface. The Bayport Limestone is described locally as a grey limestone. The Bayport Limestone varies from 10 to more than 100 feet thick in the state and is regionally composed of light to dark gray fossiliferous limestone and dolomite interbedded with quartz siltstone and sandstone. The formation may also contain chert concretions in certain zones. The Saginaw/Parma/Bayport interval is approximately 20-100+ feet thick below the proposed WWT Well No. 1 location. The Glacial Drift and Saginaw/Parma/Bayport intervals are discussed in more detail in Section 2.D of this document where the USDW is characterized and defined.

- Michigan Formation: Interbedded shale, sandstone, gypsum/anhydrite, and carbonates. Dolomite is described as tan, microcrystalline and dense, argillaceous with interbedded gray shale being firm, and calcareous. Anhydrite/gypsum is described as white/translucent to light gray, firm to moderately hard with light gray shale stringers. Siltstones are described as consolidated, and light green in color with interbedded shale. The Stray sandstone is at the base of the Michigan Formation and it described as a white, hard sandstone. The Stray Sandstone occurs at or near the base of the Michigan Formation and is described as a clear sandstone that is frosted, very fine to fine grained angular subangular consolidated calcareous sandstone. The Michigan Formation is approximately 487-567 feet thick in the proposed WWT Well No. 1 location.

- Marshall Sandstone: The Marshall occurs at the base of the Michigan Formation and is described as consisting of red sandstones, the grains of which are frosted to clear and angular to subangular. Locally, it is medium to very fine grained, and unconsolidated to loosely consolidated. It is approximately 150-200 feet thick below the Wexford County Landfill.

- Coldwater Shale: The Coldwater Shale is described as light gray to gray in color, very fine grained to slightly silty, soft, gummy shale with some blocky or platy intervals, slightly calcareous. It is approximately 744 feet thick below the Wexford County Landfill.

- Sunbury Shale: The Sunbury is distinct from the overlying Coldwater Shale in that it is brown to dark brown/black in color with interbedded light green to red intervals, it can be slightly calcareous with grace of light brown dolomite and scattered organic material. It is approximately 51 feet thick below the proposed WWT Well No. 1 location.

- Ellsworth Shale: This interval is composed of shale described as light green to gray, very fine, bulky-platy to firm in texture; it can be lightly calcareous with a trace of pyrite. It is approximately 490 feet thick below the proposed WWT Well No. 1 location.

- Antrim Shale. The Antrim is described as a dark Brown/gray/black shale that is described locally as waxy, firm, and carbonaceous. It is approximately 310 feet thick below the proposed WWT Well No. 1 location.

In total, the Antrim-Coldwater section is approximately 1,603 feet thick at the Wexford County Landfill location. Figure F-23 is an isopach of the Coldwater-Antrim section at the Wexford Facility Location, and Figure F-24 is a structure contour map constructed at the top of Coldwater. The Antrim-Coldwater section is the primary UIC confining zone for the purpose of this permit application.

Little petrophysical data for the Antrim-Ellsworth-Coldwater section is available in published literature. However, the sealing nature of shale intervals is endorsed in a number of documents. For example, Liu et all (2011) state that shales and other clay-rich sediments have a number of attributes such as very low permeability and a capacity for self-sealing, also stating that "Permeability values of clays and mudstones were… found to range from about 10 microdarcies (10^{-17} m2 or about 10^{-10} m/s) down to about 10 picodarcies (10^{-23} m^2 or about 10^{-16} m/s)." Maryn (1994) states that "Matrix porosity measurements of core samples from the Upper Black, Middle Gray and Lower Black [Antrim], ranged from 7 to 12 %, 6 to 10 %, and 6 to 14 %, respectively. The average matrix porosity was on the order of 10%". The permeability measurements of wells in productive areas of the Antrim Shale averaged 0.2 md and 0.6 md for gas and water, respectively. The Antrim Formation exhibits natural fractures elsewhere in the basin particularly near subcrop. In other areas, the Antrim serves as a confining layer for various Traverse injection well completions while the Ellsworth serves as a confining layer for the Antrim.

2.F.2.1.2 Traverse Group

The Traverse Group is a thick carbonate sequence composed of limestone and dolomite, with interbedded shaley sequences. Locally, the Traverse is described as composed of calcareous shale at the upper Traverse Formation gradational contact below the Antrim Shale, becoming progressively more carbonate rich down section. The shallowest portion of the Traverse Formation above the Traverse Limestone is considered an aquiclude and will arrest vertical fluid flow. The Traverse "Limestone" is described at Well 39695 (Figure B-1) as a dolomite that is tan to light brown in color, microcrystalline to very finely crystalline with traces of fossils and good vugular porosity in the upper 60 feet of the interval. Beds below are described as dolomites also with varying development of vugular porosity, becoming more limestone-rich in the lower half of the Traverse Group. Limestone is described as brown to medium brown in color, occasionally argillaceous, with very fine grained to micro crystalline porosity. The Traverse Group, including the Bell Shale (discussed separately, below) is approximately 689 feet thick below the proposed WWT Well No. 1 location (Figures F-25a and F-25b) based on well log and cross section information; excluding the Bell Shale, regional data agree that this unit is about 600-700 feet thick.

The proposed WWT Well No. 1 injection zone is expected to include both the upper dolomite and lower limestone members of the Traverse Group. There is very little modern petrophysical data specific to the Traverse Formation in the Wexford area. Based on a single local well with adequate well logs (Well Permit 39695, the Missaukee Lakes 1-29 Well located in Section 29 (SWSWSW) in T23N R9W) the Traverse is about 625 feet thick and varies from 2-15% neutron porosity, with various shale-rich tight stringers that occur throughout. The traverse at the Missaukee Lakes 1-29 Well exhibits:

- 545.5 feet > 4% neutron porosity,
- 513 feet > 6% neutron porosity
- 450.5 feet > 8% neutron porosity
- 348 feet > 10% neutron porosity

- 120 feet > 15% neutron porosity

Also, Well 28535 (about 5 1/2 miles north of the landfill, Figure B-1) shows significant Traverse porosity, with over 100 feet of the Traverse exhibiting greater than 15% neutron porosity. Additionally, core data suggest porosity development in the Traverse in the WWT Well No. 1 area. For example, Well Permit No. 16171 collected two Traverse cores from the 3,185-3,164 foot interval, described as containing grey shale, argillaceous limestone and dolomite. The dolomite was brown, highly vugular and coarsely crystallite with gas and salt water. These data, while distant from the proposed WWT Well No. 1 location site, indicate the occurrence of regional Traverse porosity development.

Of the 30 or more wells within the five mile radius around the landfill, many are over 70-80 years old, having been drilled in the 1930s and 1940s. Data for these wells are limited and geophysical well logs were not found, but driller's comments typically state that water was usually encountered in the Traverse during drilling, indicating that the Traverse contains sufficient porosity and permeability to contain what appears to be large volumes of water. For example, Well Permit 25348, about 4 miles southeast of the site, was originally drilled to produce oil/gas from the Traverse, but there were only minimal hydrocarbon shows and the well produced a significant quantity of highly saline water. As a result, Well Permit 25348 was converted to a brine production well, and served in this capacity until the producer apparently lost the brine client and the well was subsequently abandoned within the past 10 years.

Table F-2 summarizes available Traverse information that indicates potential Traverse porosity development:

Table F-2
Traverse Well Data Indicating Potential Porosity Development

Permit No	API Well No	Date Drilled	Evidence of Traverse Permeability and Porosity Development
11830	21113118300000	1945	TD 3853 Detroit River. Elog has hand-written identification of "permeable" zones of Dundee identified and similar, multiple clean zones in upper Traverse. P/A[1].
16171	21113161710000	1950	TD 5136 Detroit River. Driller's log indicates Traverse is vugular and bleeding gas. The Traverse was cored with several permeable carbonate intervals identified. P/A
23783	21113237830000	1962	TD 3843 in Dundee. Traverse had show of oil at top, 940 ft water 1/3 bbl oil 4 hrs at 3074. P/A.
39695	21113396950000	1986	TD 4145 Detroit River. Traverse lime originally produced oil with heavy water cut. "Closed in" 1986. Reworked "Antrim" 1989- plugged back to 2983, although well plug had lost control/circulation at 3250 (Traverse, indicating porosity). Well was ultimately P/A due to extreme water production presumably in association with the uppermost Traverse/base of Antrim. P/A
1125	21165011250000	1931	TD 4141 Detroit River. Show of oil at top of Traverse lime, "hole full of water" at 3216 drilled in 1931 with cable tools. P/A
1398	21165013980000	1932	TD in Detroit River 3970. "Water" specified in drillers log, both the upper Traverse and Dundee. P/A
2352	21165023520000	1935	TD 3868 in Dundee, plugged back to 3190. 2200 feet of oil [and presumably water] in hole at 3180 ft in the Traverse. P/A
9198	21165091980000	1942	TD 3917 Detroit River. Hole full of water at top of Traverse 3115 and found again at 3412. P/A
10661	21165106610000	1944	TD 3989 Detroit River Water at 3062 in Traverse. P/A
11008	21165110080000	1944	TD 3916 Dundee. Saginaw basement. Hole "full of water" in Traverse lime 3082-3097 and Dundee. P/A
14307	21165143070000	1948	TD 3678 Detroit River or Dundee. Water at 2837 in Traverse. P/A
17109	21165171090000	1951	TD in Traverse at 3270. Porosity 3132-3136, 3215-3248, oil 3220-3226, oil/water 3229-3235; porosity 3256-58. DST recovered 2400 ft salt water. CORE 3226-3240, 3240-3255. P/A
25348	21165253480000	1964	TD in Traverse 3236. Well was drilled to 3208 as dry hole (produced water during drilling), but later deepend to 3236 and completed as Traverse brine well in 1964. P/A.

[1] P/A = plugged and abandoned

As indicated in Table F-2, even though most wells were not geophysically logged, associated drillers logs from several of the wells imply that there are porous zones within the Traverse based on the occurrence of significant water production. These zones produced no marketable quantity of hydrocarbon and were not pursued as oil and gas wells, but the fact that significant porosity zones were encountered that "gave up water" means that there is likely sufficient Traverse porosity available to serve as a potential injection interval.

The Leelanau Fruit Company in Northern Wexford County has a permitted Class I injection well in the Traverse (and Dundee) Formations. The Traverse at Leelanau near Buckley, Michigan is described locally as containing tan-brown dolomites that are microcrystalline, with buff to cream limestone with stringers of dense dolomites that are tan-buff in color. The Traverse Group at Leelanau, including the Bell Shale is approximately 700 feet thick. Excluding the Bell Shale the Traverse is about 615-650 feet thick in the Leelanau area. These data are consistent with available Traverse information for the Wexford County Landfill area. At Leelanau, the injection zone includes limestone and dolomite members of the Traverse for which the porosity in a 567 ft thick interval appears to vary from 2% to over 30% porosity, with approximately 97 ft of greater than 9% porosity carbonate occurring in the interval. The thickness, porosity, and requested injection rate for Leelanau are consistent with that of the proposed WWT Well No. 1 location site, demonstrating that the Traverse is a viable injection target in Wexford County.

2.F.2.1.3 Bell Shale

The Bell Shale is a thick shale sequence that occurs throughout most of the Michigan Basin (Figure F-10). Wylie and Huntoon (2003) show that Bell Shale occurs throughout almost all of Michigan except for the lower southwest corner of the Lower Peninsula, stating that the Bell Shale is up to 110 feet thick with an average subsurface thickness of 80 feet. Figure F-10 presents the Bell Shale thickness as mapped by Milstein (1985), showing that the Bell Shale is about 70 feet thick below the Wexford County Landfill property, which is generally consistent with area data (Figure F-26) that verify the Bell Shale is approximately 56-57 feet thick below the Wexford County Landfill. Milstein's' map (Figure F-10) shows the thickest Bell Shale occurrences are in the northwestern portion of the state, including Antrim, Leelanau, Kalkaska, Grand Traverse, Manistee, and Benzie counties. Montgomery et. al. (1998) stated that the Bell Shale of the Traverse Group overlies the Dundee, and is a "fossiliferous transgressive marine shale" that is composed of micritic (i.e. limestone) muds and clays that were deposited atop the Dundee. Bell Shale core descriptions (Wood 1996) indicate the lower Bell Shale is a dark gray shale with numerous fossiliferous zones that can be "massive and pyritic". Other authors also describe the Bell Shale as a carbonate-rich, argillaceous, sometime carbonaceous, massive gray shale.

The Devonian age Bell Shale is typically a soft, gray, gummy and silty shale containing scattered fossil fragments. In the local vicinity, the Bell Shale is projected to be comprised of almost 50 to 100 feet of medium green to green-gray shale overlain by a sequence that transitions to a limestone and dolomite dominated sequence. Transmissive fractures are not known to be present in this shale.

2.F.2.1.4 Dundee Formation

The Dundee Formation is described as a carbonate sequence composed of cream-brown mottled limestones and dolomites with occasional anhydrite stringers. The carbonates are described as fine to microcrystalline. Figure F-27a is a local structure contour map constructed at the top of the Dundee. The Dundee is composed of the Rogers and underlying Reed City Members. Because many local wells did not fully penetrate the Dundee, local data indicate that the Rogers Member is likely approximately 127 feet thick. Regional data suggest the Dundee (including the Reed City Member) is approximately 150-200 or more feet thick below the Wexford County Landfill. Figure F-27b is a local isopach map of the Dundee constructed based on well log descriptions. It should be noted that many wells did not fully penetrate the Dundee, so this local isopach likely represents the thickness of the upper Rogers unit.

As with the Traverse, there is only one modern Dundee geophysical well log within five miles of the Wexford County Landfill, Well Permit No. 36965. This well shows there is a 10-20 foot thick Dundee zone of 6-8% porosity immediately below the Bell Shale, although the pervasiveness of porosity development in this portion of the Dundee cannot be verified over any significant area due to lack of data. Similarly, lithologic descriptions written on the well log at Well 11830 (Figure F-20), verify the presence of a 20 ft thick "permeable" limestone at the top of the section, with low permeability/porosity limestone below this zone. Well Permit No. 16171 was cored in the Dundee; six (6) cores were collected between 3,788-3,913 feet. Cores indicate that there is a grey shale at the top of cored sequence (presumably lower Bell Shale), with dolomite and limestone (tight to fossiliferous) at the top of the sequence. Limestone is the predominant lithology in upper portions of the cored interval with the base being dolomite described as crypto to very finely crystalline with interbedded anhydrite. The basal Dundee core was dolomite, brown to buff, exhibiting vertical fractures, joints, and good vugular porosity. A DST of the Dundee produced 1,130 feet of saltwater. Also, evidence of Dundee porosity is supported by a drill stem test conducted at Well Permit No. 24514 (Figure F-20) with results as follows:

> Interval 3,621-3,649 feet (Dundee):
> Limestone, brown, detrital, some chalky and weathered in appearance; limestone, darker brown, finely crystalline, some dolomitic (Drill Stem Test #1: 3,628-3,661 feet, open 1 hour, shut in 60 minutes, final shut in 1 hour 30 minutes, recorded 30 feet drilling mud, THMP 1938, ICIP 1203, IFP 22, FFP 22, FCIP 1153, FHMP 1927, corrected, IHMP 1932, ICIP 1202, IFP 13-25, FFP 13-20, FCIP 1150, FHMP 1924)
>
> Interval 3,729-3,738 feet (Dundee):
> Dolomite, buff to brown, finely crystalline to micritic; anhydrite, white, gray, gray brown (Drill Stem Test #2: 3,725-3,850 feet, open 1 hour, shut in 30 minutes,

final shut in 1 1/2 hours, recovered 360 feet drilling fluid and 740 feet black salt water, IHMP 1844, ICIP 1285, IFP 29-208, FFP 181-567, FCIP 1284, FHMP 1828)

Additionally, the data on Table F-3 were obtained when wells were drilled which indicate that permeable, water-yielding intervals are present within the Dundee:

Table F-3
Dundee Well Data Indicating Potential Porosity Development

Permit No	API Well No	Date of Well installation	Evidence of Dundee Permeability and Porosity Development
9534	21113095340000	1942	TD 5,080 feet in Detroit River. 500 feet water at base of Dundee. Underlying Monroe/Lucas, 5 bailers of water in 8 hours, well "exhausted itself".
11830	21113118300000	1945	TD 3,853 feet in Detroit River. Cored 3,644-3,655 feet Dolomite, bleeding oil, salty at base. Elog labels 24 feet interval of "permeable limestone" below Bell Shale. LS and Dolomite to 3,755 feet; anhydrite at 3,755 feet. DST in Dundee yielded 1,300 feet water/show oil. Paperwork submitted to convert to Dundee disposal well in 1982, but this was never finalized.
13525	21113135250000	1947	TD 3,822 feet in Detroit River. DST at 3,815-3,822 feet. Yielded 500 feet water. Possible Dundee test.
16171	21113161710000	1950	TD 5,136 feet in Detroit River. Michigan identified as bedrock below drift. Dundee cored 3,788-3,988 feet. Dundee top DST 45 feet SW. Dundee described as dolomitic throughout, with dolomite at base exhibiting vugular porosity. Lower zone DST got 1,130 feet BW. Richfield (Lucas) also cored.
23783	21113237830000	1962	TD 3,843 feet in Dundee. Well file indicates porosity at 3,807 feet, no oil shows in Dundee.
39695	21113396950000	1986	TD 4,145 in Detroit River. Upper 20 feet of Dundee 18% nphi. Tight zone 3,732-3,796 feet. Remainder around 10%.
1125	21165011250000	1931	TD 4,141 feet in Detroit River. Oil show in Dundee at 3,950 feet; Water in Dundee at 3,955 feet.
1398	21165013980000	1932	TD 3,970 feet in Detroit River. Water in Dundee at 3,765 feet.
2352	21165023520000	1935	TD 3,868 feet in Dundee, plugged back to 3,190 feet. "Black water show oil" in Dundee.
4584	21165045840000	1937	TD 3,920 feet in Detroit River. Black water at 3,300 feet in Dundee
8906	21165089060000	1942	TD 4,010 feet in Detroit River. Water in Dundee 3,890-3,895 feet.
9198	21165091980000	1942	TD 3,917 Detroit River, no geophysical log. Water in Dundee 3,804 feet; 3,000 feet 20 hrs on DST.
10247	21165102470000	1943	TD 3,900 feet in Detroit River. Cored 3,710-3,717 feet; 5 foot porosity in Dundee. DST recovered 120 feet OCM, 210 feet water. Cored 3,847-3,880 feet, dolomite/anhydrite (Reed City). Hole full of water after perforations 3,700-3,712 feet; also perforated 3,835-3,842 feet. E log was labeled in three Dundee zones as permeable limestone (total 10 feet).
10661	21165106610000	1944	TD 3,989 feet in Detroit River. Show of oil Dundee 3,682-3,685 feet; Water 3,693 feet. Dundee described as medium to coarsely crystalline.
11008	21165110080000	1944	TD 3,916 feet in Dundee. Hole "full of water" in Traverse Lime 3,082-3,097 feet and Dundee 3,906-3,914 feet.
14307	21165143070000	1948	TD 3,678 feet in Detroit River-Dundee. Water in Dundee 3,675-3,678 feet.

The Leelanau Fruit Company well penetrated the Dundee, and in the 1970's initially was completed into this interval as the only injection zone; the Traverse was later added to increase injection capacity. The Dundee at Leelanau is described as a carbonate sequence composed of cream-brown, fine to microcrystalline mottled limestones and dolomites with occasional anhydrite stringers. The Leelanau well file describes the Dundee as being composed of a 73-89 feet cream to buff colored limestone near the top, with an approximately 26 feet thick anhydrite zone occurring below this limestone-rich interval. Between the uppermost anhydrite and the Detroit River, this interval is composed to interbedded dolomites, anhydrites and limestones varying in thickness from 18-34 feet. Dundee carbonate porosity at Leelanau, based on the QUAST 1-1 well, was projected to range from about 2% to over 15%, with about 46 ft of greater than 9% porosity. While the Leelanau well is approximately 16 miles from the Wexford County Landfill, these data indicate that there may be sufficient Dundee porosity within the county to support injection activities.

These data indicate that sufficient porosity may be present within the Dundee to produce what is described as large quantities of water, and lithologic descriptions indicate the potential presence of porosity development within the Dundee. Data imply that, combined with the Traverse Limestone, the Dundee is part of the primary target for the WWT well at the Wexford County Landfill site.

2.F.2.1.5 Detroit River Group, Bois Blanc Formation, and Bass Islands Group

The remaining Devonian-age rock groups below the Dundee, as well as Upper Silurian age Bass Islands Groups contain potential injection targets if the Traverse and Dundee do not demonstrate sufficient injection capacity. Specifically, the Amherstburg, Sylvania Sandstone/Equivalent, Bois Blanc and/or Bass Islands may be injection targets, if required. These units are described below.

The Detroit River Group includes the Lucas (including the Richfield) Formation, Amherstburg Formation and, where present, Sylvania Sandstone. Note that the shallowest part of the Detroit River is not being described as part of the Dundee for the purpose of this document. Figures F-22a- F-22c are regional cross sections that show the occurrence of these units across Wexford County.

The Lucas Formation occurs below the Dundee, and is composed of upper interbedded salts, dolomites and anhydrites and a lower porous dolomite Richfield Member as assigned by Landes (1951). Very few wells penetrate through the Detroit River within 10+ miles of the Wexford County Landfill, so data pertaining to formation characteristics at and below the Detroit River are obtained from regional data. Well Permit No 16171, located east of the Wexford County Landfill, exhibits over 700 feet of interbedded carbonates, anhydrites, and salts of the Lucas Formation, and the lowermost Richfield member was cored at this location. In total, five (5) Richfield cores between 4,900 and 5,100.3 feet were collected. The upper 130 feet or more of the core is described as interbedded anhydrite and dolomite. The remaining bottom portion of the core was composed of interbedded dolomite in limestone described as "dense", with occasional interbedded sandstone in lower 50 feet of core. Local data suggest that the Detroit River (excluding the Richfield) is approximately 734 feet thick below the proposed WWT Well No. 1 location, and the Richfield member is approximately 235 feet thick.

Milstein (1983) indicates that up to 500 feet of salt-bearing Detroit River (Lucas) zones may be present in the greater Michigan Basin, and there is approximately 700 feet of interbedded carbonates and salts at Well Permit 16171, 6 miles east of the Wexford County Landfill. Regionally, sandstone intervals may occur at or near the base of the Lucas/Richfield, verified in core from Well Permit 16171 that showed the presence of a thin sandstone interval in at 5,031-5,036 feet. In total, the Detroit River Group is approximately 950-1,000 feet thick below the Wexford facility. The presence of thick salt intervals, anhydrites, and tight or dense carbonates supports the viability of these portions of the Detroit River as confining zones for underlying intervals.

The Amherstburg Formation occurs below the Lucas Formation. The Amherstburg is described by Barnes et al (2009) as consisting mostly of limestone and subordinate dolomite, with basal dark brown to black limestone (Meldrum Member). Thin "Filer" sandstone(s) is also present in western portions of the state. Little detailed information concerning the Amherstburg is available in the Wexford area. Regional data at Well Permit No. 40861 approximately 10 miles south of the Wexford County Landfill indicate that the Amherstburg at this location is composed of lower porosity (2-8%) dolomites with interbedded "Filer" sandstones. Well Permit 28535, approximately 7 miles north of the proposed WWT Well No. 1 location is the closest deep well which shows there to be a relatively distinct neutron porosity response in the Amherstburg that correlates well with the more distal dolomitic interval at Permit 40861(Figure F-22a). Well Permit No 35099 occurs approximately 8 miles north of the facility and shows an even more distinct porosity zone development in the Amherstburg. Porosity in the Amherstburg at Well Permit 35099 is apparently greater than 15% within a 70 ft. thick zone between 4,152-4,230 ft. RKB. These data indicate the presence of substantial porosity development in what correlated to be the Amherstburg or "Filer" Sand, however, the lateral continuity and characteristics of this porosity zone below the proposed WWT Well No. 1 location cannot be verified due to lack of local data. Assuming regional continuity of the interval as shown in Figure F-6, the Amherstburg is approximately 215 feet thick below the proposed WWT Well No. 1 location. A portion of this thickness has potential as injection zone. It should also be noted that at least one Amherstburg injection well (Permit No. 32223) is present in Falmouth Field, in neighboring Missaukee County. Porosity development in the Richfield or Amherstburg is a possibility based on both local and regional data although Barnes et al (2009) also recognized the sealing capabilities of the Amherstburg in central portions of the state including Otsego County.

The Sylvania Formation occurs conformably below the Amherstburg and, based on regional data, contains a thick, correlatable, porous interval (Figure F-22a). For example, the interval occurs about 4,394 ft /RKB at Well Permit 35099, extending to 4,634 ft (approximately 240 feet thick). Log porosity is very high (greater than 25% in many intervals). However, the lithology of the "Sylvania" is difficult to ascertain based on regional data. Well Permit 28535 indicates the Sylvania is composed of fine, well sorted sandstone with interbedded limestone. In contrast, Well Permit 35099 identifies the same interval as being composed of limestone and dolomite, with traces of sandstones. Lithologic cross plot results at Well Permit 40861 indicate the unit is composed of limestone-rich intervals with interbedded sandstones. These data together suggest that the Sylvania compositionally and physically changes dramatically throughout the region. Based on cross section F-22a, b and c, the Sylvania may be over 250 feet thick below the proposed WWT Well No. 1 location site and is a potential injection zone target.

The Bois Blanc also holds promise with respect to porosity development in a cherty-filled horizon, as does the underlying Bass Islands. Barnes et al (2009), summarized CO2 assessments in these zones as follows:

> "Existing subsurface data and data from core and logs in a new CO2 pilot injection test well drilled in northern lower Michigan were used to evaluate the geological carbon sequestration (GCS) potential in Upper Silurian to Middle Devonian saline reservoir and caprock units in the Michigan Basin. The Core Energy-State Charlton #4-30 well, Otsego County, Michigan, was drilled as part of ongoing Midwest Region Carbon Sequestration Partnership (MRCSP) phase II studies to investigate GCS potential in these units in the Michigan Basin. Significant GCS potential is recognized in porous dolomite of the Upper Silurian, Bass Islands Group in the new well. Cherty strata of the Bois Blanc Formation are also present in the #4-30 well but may lack suitable injectivity for consideration of GCS. Argillaceous limestone in parts of the superjacent Amherstburg Formation in the test well contains minimal porosity and permeability and constitutes an excellent cap-rock unit in the area. Regional consideration of the Bass Islands sequestration target interval indicates substantial GCS potential throughout most of the Michigan Basin."

A regional cross section that passes just south of the proposed WWT Well No. 1 location site was created by Harrison et al (2009). This cross section shows substantial development of Bois Blanc cherts, with no mapped Sylvania sandstone in the area based on this regional cross section. However, as shown in Figure F-22a, lateral facies changes within the Sylvania vary greatly, and based on available information the Sylvania is indeed present below Wexford although the sand content of the interval is variable as evidenced by regional data. The Bois Blanc is approximately 200 feet thick in the rea and the Bass Islands is approximately 350 feet thick based on regional data and area also potential injection zone targets.

2.F.2.2 Local Structural Geology

Figures F-25a and F-27a are local structure contour maps constructed at the top of the Traverse and Dundee, respectively. Both maps show a there to be no major structural features in the area, with beds dipping approximately 22 ft/mile to the south-southeast on the Dundee surface, and about 40 ft/mile generally to south at the top of the

Traverse. Neither of the maps indicate the presence of any identifiable faults, and both suggest the presence of minor folds in the area.

2.F.2.3 Seismicity

The North Central portion of the Michigan Basin is designated as a minor seismic risk area by the USGS (http://earthquake.usgs.gov/regional/states/michigan/hazards.php). The area has a peak ground acceleration of 2-4 percent g, 2% in 50 years projected ground acceleration (Figure F-28).

On May 2 2015, a 4.2 magnitude earthquake occurred in Southwest Michigan. The USGS states the earthquake epicenter was 12 Km (7 miles) east of Portage and 15 km (9 miles) southeast of Kalamazoo. The USGS also indicated that the hypocenter or focus (depth at which it occurred) was 5.9 km, or about 19,500 feet below ground surface. Subsequently in June of 2015, a much smaller 3.3 magnitude event occurred about 20 miles to the east, northeast of Union City. Both earthquakes were likely naturally occurring, according to the USGS (2015). Historic data from USGS suggest that small earthquakes have occasionally been felt in the region since 1881, but none of these epicentered within 50 miles (80.4 km) of the Wexford County Landfill.

There have been two earthquakes in Michigan that exceeded a 4.1 Richter magnitude. The largest magnitude earthquake that occurred in Michigan was felt in southern Michigan near the town of Kalamazoo where an earthquake with a magnitude greater than 4.5 occurred more than 60 years ago on August 9, 1947. Figure F-29 shows the location of this earthquake, the epicenter of which was actually in Indiana (USGS, 2014). It damaged chimneys and cracked plaster over a large area of south-central Michigan and affected a total area of about 50,000 square miles, including points north to Muskegon and Saginaw and parts of Illinois, Indiana, and Wisconsin. The cities of Athens, Bronson, Coldwater, Colon, Matteson Lake, Sherwood, and Union City in the south-central part of the State all experienced intensity VI effects. This earthquake was centered over 35 miles southeast of Kalamazoo (USGS, 2014), but the isoseismal map indicates it was minimally or not felt at or near Cadillac, Michigan.

Table F-4 shows the location where Michigan earthquakes occurred between 1887 – 1994 (USGS, and Bricker, 1977). Table F-4 is based on various references and is intended to show general location and identification of recorded earthquakes; it may not be complete.

Table F-4
1872 – 1994 Michigan Earthquakes and Distance in Km from the Wexford County Landfill

Year	Month	Day	North Latitude	West Latitude	Intensity (Mercalli)	Approximate Radial Distance from Wexford (Km)
1872	02	02	43.6	-83.9	IV	147.1
1876	01	27	41.8	-84.05	No Data	304.1
1876	02	27	42.36	-82.83	No Data	304.2
1887	08	17	42.36	-83.16	IV	286.5
1881	04	20	41.6	-85.8	IV	306.9
1883	02	04	42.3	-85.6	No Data	227.9
1897	10	31	41.8	-86.3	No Data	292
1899	10	11	42.1	-86.5	IV	264.6
1899	10	12	42.6	-87.8	III	273.1
1905	03	13	41.13	-87.6	V	399.4
1906	04	22	43.1	-87.9	III	242.8
1906	04	24	43.0	-87.9	III	249.4
1906	05	19	42.9	-85.7	III	162.3
1907	01	10	45.13	-86.33	V	113.1
1918	02	22	42.8	-84.2	IV	197.9
1925	03	03	42.1	-87.7	II	310.6
1938	02	12	41.6	-87.0	V	331.3
1938	03	13	42.36	-82.83	IV	304.2
1947	05	06	43.0	-87.9	V	249.4
1947	08	10	41.9	-85.0	VI	274.1
1956	07	18	43.6	-87.7	IV	200.5
1956	10	13	42.9	-87.9	IV	256.3
1967	02	02	42.7	-84.6	IV	194.5
1981	01	09	43.1	-87.9	II	242.8
1994	09	02	42.8	-84.6	IV	184.1

* From Bicker, 1997 and USGS, 2014

Available data indicates that recorded earthquakes in Michigan have typically been mild and had epicenters far outside of the Wexford County Landfill AOR. None of the historically reported earthquakes were of sufficient intensity to cause damage to any surface or subsurface structures at the Wexford facility. It should be noted that the USGS seismic monitoring system is sensitive enough to detect earthquakes down to a magnitude of less than 1 as indicated on the USGS's real-time earthquake monitoring website (http://earthquake.usgs.gov/ earthquakes/recenteqsus). Table F-5, prepared by the USGS and presented below, compares magnitude and intensity:

Table F-5
Earthquake Magnitude vs. Intensity Comparison

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 – 3.0	I
3.0 – 3.9	II – III
4.0 – 4.9	IV – V
5.0 – 5.9	VI – VII
6.0 – 6.9	VII – IX
7.0 and higher	VIII or higher

(Source: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php)

Injection-induced earthquakes have occurred infrequently in other areas of the country including more recently in Kansas and Oklahoma, particularly in areas with recent high rate/high volume Class II well activity. Fluid injection-induced earthquakes are typically attributed to increased pore pressure from injection operations, reducing frictional resistance to failure.

EPA issued a report entitled "Minimizing and Managing Potential Impacts of Injection-Induced Seismicity from Class II Disposal Wells: Practical Approaches" (2014). The document was prepared by a Technical Work Group and indicates that the following characteristics are all necessary for significant injection-induced seismicity to occur: 1) sufficient pressure buildup from disposal activities, 2) presence of Faults of Concern, and 3) a pathway allowing the increased pressure to communicate to the fault. In the case of WWT Well No. 1 and as shown in regional and local structure contour maps (i.e. F-2a, F-8, F-11, F-24, F-25a and F-27a), there is no evidence of faulting in the area either at basement or within the shallower geologic units targeted for injection. Extensive review of publicly available maps did not identify the presence of any mapped faults in the WWT No. 1 area and although lineaments occur far to the east of the site (Figure F.8-19), these have not been mapped to extend to Wexford County. Also, while the site occurs within the ancient Mid Continental Rift area, this system is long healed/sealed and is a paleo remnant of a billion year old plate boundary. Therefore, available data do not indicate the presence of any fault in the area, especially one that is "optimally oriented for movement and located in a critically stressed region". Furthermore, approximately 6,000 feet of bedded carbonates, sandstones, and shales occur between the base of the deepest potential injection zone at the WWT Well No. 1 location and Precambrian basement. The closest borehole that extends to a deeper zone below the deepest proposed injection zone, PN 35099 drilled to the Prairie Du Chien at 10,100 feet, is approximately 10 miles to the northwest of WWT No. 1; this well is an old brine disposal well that was plugged in 1984 that was not associated with any induced seismicity. Pressure calculations show that pressure drops to less than 75 psi of build-up at 2 miles from WWT No. 1 based on conservative calculations, indicating that even if the PN 35099 borehole is somehow compromised and a conduit to deeper rock units exists near a here-to-fore unidentified basement fault, there is insufficient calculated pressure rise to cause any impact at the identified well location. In short, due to the lack of identified faults, low calculated pressure build up, stable geologic conditions, and lack of proximal conduits, the chance of any induced seismicity event attributable to WWT Well No. 1 activities is not expected and is extremely remote.

No induced earthquakes have been known to occur in Michigan. In cases where injection is thought to have caused seismicity, significant injection pressures and injection volumes have often been involved as well as proximity to basement faults (KGS, 2015; Seeber et al. 2004; Wesson and Nicholson, 1987). However, no earthquakes have had epicenters within 50 miles of the Wexford County Landfill, and there is no evidence to indicate that any injection-induced seismic activity has or will occur in the Wexford County Landfill area.

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STRATIGRAPHIC NOMENCLATURE FOR MICHIGAN

Michigan Dept. of Environmental Quality
Geological Survey Division
Harold Fitch, State Geologist
and
Michigan Basin Geological Society

Stratigraphic Nomenclature Project Committee:
Dr. Paul A. Catacosinos, Co-chairman
Mr. Mark S. Wollensak, Co-chairman

Principal Authors:
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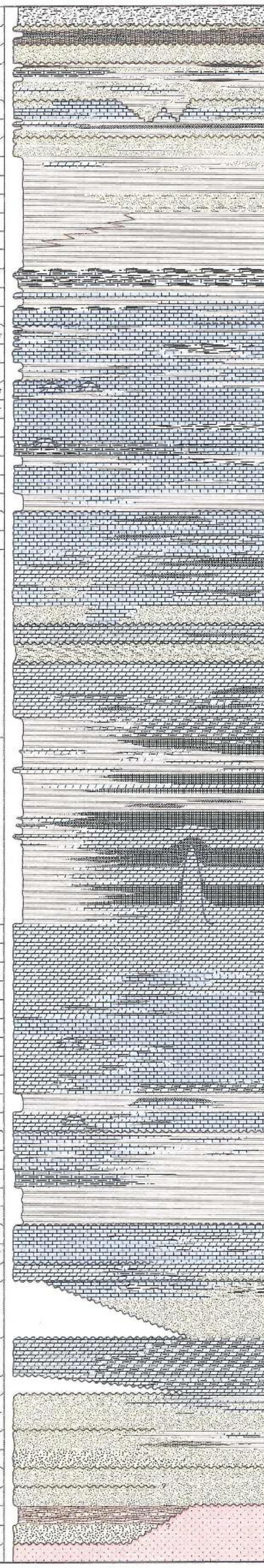
Mr. Mark S. Wollensak

2000

GEOLOGIC TIME				OUTCROP NOMENCLATURE			SUBSURFACE NOMENCLATURE	
ERA	PERIOD	EPOCH	NORTH AMERICAN STAGES	GROUP	FORMATION	MEMBER	FORMATION	GROUP
Cenozoic	Quaternary	Pleistocene	Wisconsinan	Glacial Drift			Glacial Drift	
Mesozoic	Jurassic	Middle	Oxfordian		Ionia Fm		Ionia Fm	
Paleozoic	Pennsylvanian	Late	Conemaugh		Grand River Fm		Grand River Fm	
		Early	Pottsville		Saginaw Fm		Saginaw Fm	
					Parma Ss		Parma Ss	
	Mississippian	Late	Meramecian		Bayport Ls		Bayport Ls	
					Michigan Fm		Michigan Fm	
		Early	Osagian		Marshall Ss		Marshall Ss	
			Kinderhookian		Coldwater Sh		Coldwater Sh	
					Sunbury Sh		Sunbury Sh	
	Devonian	Late	Chautauquan	Ellsworth Sh (western)	Berea Ss (eastern)		Ellsworth Sh (western); Berea Ss (eastern)	
					Bedford Sh (eastern)		Bedford Sh (eastern)	
					Antrim Sh	Upper Mbr	Upper Mbr; Antrim Sh	
						Lachine Mbr	Lachine Mbr	
						Paxton Mbr	Paxton Mbr	
						Norwood Mbr	Norwood Mbr	
			Senecan		Squaw Bay Ls		Squaw Bay Ls	
		Middle	Erian	Traverse Gr	Thunder Bay Ls	Partridge Point Mbr	Traverse Ls	Traverse Gr
						Potter Farm Mbr		
						Norway Point Mbr		
					Alpena Ls	Four Mile Dam Mbr		
						Newton Creek Mbr		
					Long Lake Ls	Killians Mbr		
						Genshaw Mbr		
					Ferron Point Fm			
					Rockport Quarry Ls			
					Bell Sh		Bell Sh	
					Rogers City Ls		Dundee Ls	
					Dundee Ls			
			Ulsterian	Detroit River Gr	Anderdon Ls	Mackinac Breccia	Mackinac Breccia; Lucas Fm	Detroit River Gr
					Lucas Fm			
					Amherstburg Fm		Amherstburg Fm	
					Sylvania Ss		Sylvania Ss	
					Bois Blanc Fm		Bois Blanc Fm	
		Early			Garden Island Fm		Garden Island Fm	
	Silurian	Late	Cayugan	Bass Islands Gr	Raisin River Dol		undifferentiated	Bass Islands Gr
					Put-in-Bay Dol			
					St. Ignace Dol			
				Salina Gr	Pte. aux Chenes Fm		Salina G Unit	Salina Gr
							Salina F Unit	
							Salina E Unit	
							Salina D Unit	
							Salina C Unit	
							Salina B Unit	
							Salina A-2 Carb	
							Salina A-2 Evap	
							Ruff Fm	
							Salina A-1 Evap	
							Cain Fm	
		Middle	Niagaran	Engadine Gr	Bush Bay Fm		Guelph Dol	Niagara Gr
					Rapson Creek Fm			
					Rockview Fm		Lockport Dol	
				Manistique Gr	Cordell Fm		undifferentiated	Manistique Gr
					Schoolcraft Fm			
				Burnt Bluff Gr	Hendricks Fm	Fiborn Ls Mbr	undifferentiated	Burnt Bluff Gr
					Byron Fm			
					Lime Island Fm			
		Early	Alexandrian	Cataract Gr	Cabot Head Sh		Cabot Head Sh	Cataract Gr
					Manitoulin Dol		Manitoulin Dol	
	Ordovician	Late	Cincinnatian	Richmond Gr	Big Hill Fm		Queenston Sh	Richmond Gr
					Stonington Fm	Ogontz Mbr	Utica Sh	
						Bay de Noc Mbr		
					Bill's Creek Sh			
		Middle	Mohawkian		Collingwood Sh		Collingwood Sh	
					Trenton Fm	Groos Quarry Mbr	Trenton Fm	
						Chandler Falls Mbr		
					Black River Fm		Black River Fm	
			Chazyan	<unconformity>			Glenwood Fm	
							St.Peter Ss	
			Whiterockian					
		Early	Canadian		Au Train Fm		Foster Fm	Prairie du Chien Gr
							undifferentiated	
	Cambrian	Late	Trempealeaun	<unconformity>			Trempealeau Fm	
			Franconian		Munising Fm	Miner's Castle Mbr	Franconia Fm	Munising Gr
			Dresbachian				Galesville Ss	
						Chapel Rock Mbr	Eau Claire Fm	
						Basal Cgl	Mount Simon Ss	
Precambrian	Middle Proterozoic Eon				Jacobsville Ss		Pre-Mt. Simon Clastics	
				Oronto Gr	Freda Ss		Precambrian Crystalline Basement Complex	
					Nonesuch Sh			
					Copper Harbor Cgl			
	Archean to Middle Proterozoic Eons			Precambrian Crystalline Basement Complex				

DOMINANT LITHOLOGY



Acknowledgements

This work is the product of the combined efforts of the geological communities of Michigan and the surrounding states and provinces. Below are given just a representative few of the contributors;

Academia: Dr. Aureal T. Cross, Michigan State University; Dr. Robert H. Dott, Jr., University of Wisconsin; Mr. William O. Everham, Ph.D. Candidate. Michigan Technological University.

Government: Dr. Terry R. Carter, Ontario Ministry of Natural Resources; Mr. John M. Esch, Michigan Department of Environmental Quality, Dr. Brian D. Keith Indiana Geological Survey, Mr. Lawrence H Wickstrom, Ohio Geological Survey.

Industry: Mr. Donald J. Bailey, Consultant; Mr. Jimmy R. Myles, Scot Energy; Mr. Dan E. Pfeiffer, Pfeiffer Exploration Services.

A complete listing of all contributors will be found in the Stratigraphic Lexicon for Michigan, of which this column is an integral part.

RELATED TERM CORRELATION

STRATIGRAPHIC POSITION	RELATED TERMS
Ionia Fm	Jurassic Red Beds
Michigan Fm	Clare Dolomite, Brown Lime, Stray Dolomite, Stray Sandstone, Stray-Stray Sandstone, Stray-Stray-Stray Sandstone, Triple Gyp
Coldwater Sh	Coldwater Red Rock, Speckled Dolomite, Wier Sand
Antrim Sh	Charlton Black Shale Member, Elltrim, Chester Black Shale Member, Upper Black Shale, Light Antrim, Lower Black, Lower Antrim Middle Antrim, Middle Gray Antrim, Dark Antrim, Middle Gray Shale, Unit 1A, Unit 1B, Unit 1C, Crappo Creek Grey Shale Member
Dundee Ls	Reed City Member/Dolomite/Anhydrite
Lucas Fm	Freer Sandstone, Horner Member, Iutzi Member, Massive Salt/Anhydrite, Sour Zone, Big Anhydrite, Richfield Zone/Member/Sandstone, Big Salt
Amherstburg Fm	Filer Sandstone, Meldrum Member, Black Lime
St. Ignace Dolomite	Salina H Unit
Salina B Unit	Big Salt, B Salt
Ruff Formation	Salina A-1 Carbonate, Rabbit Ears Anhydrite,
Cain Fm	Salina A-0 Carbonate
Guelph Dolomite	Brown Niagara, Niagaran Reef, Pinnacle Reef, Engadine Dolomite
Lockport Dolomite	Gray Niagara, White Niagara
Burnt Bluff Gr	Clinton Formation
Trenton Fm	Cap Dolomite
Black River Fm	Van Wert Zone, Sneaky Peak, Black River Shale
Glenwood Fm	Goodwell Unit, Zone of Unconformity
St. Peter Sandstone	Bruggers Sandstone, Jordan Sandstone, Knox Sandstone, Massive Sand
Prairie du Chien Gr	Foster Formation, New Richmond Sandstone, Lower Knox Carbonate, St. Lawrence Formation, T-PDC, Oneota Dolomite, Brazos Shale
Trempealeau Fm	Lodi Formation
Galesville Ss	Dresbach Sandstone
Pre-Mt. Simon Clastics	Precambrian "Red Beds"

LEGEND

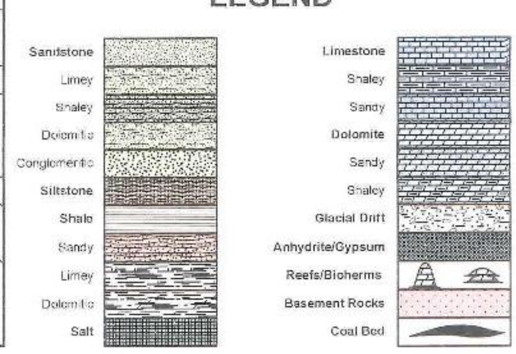


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Figure F-1
Stratigraphic Column of Michigan

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: May 2015
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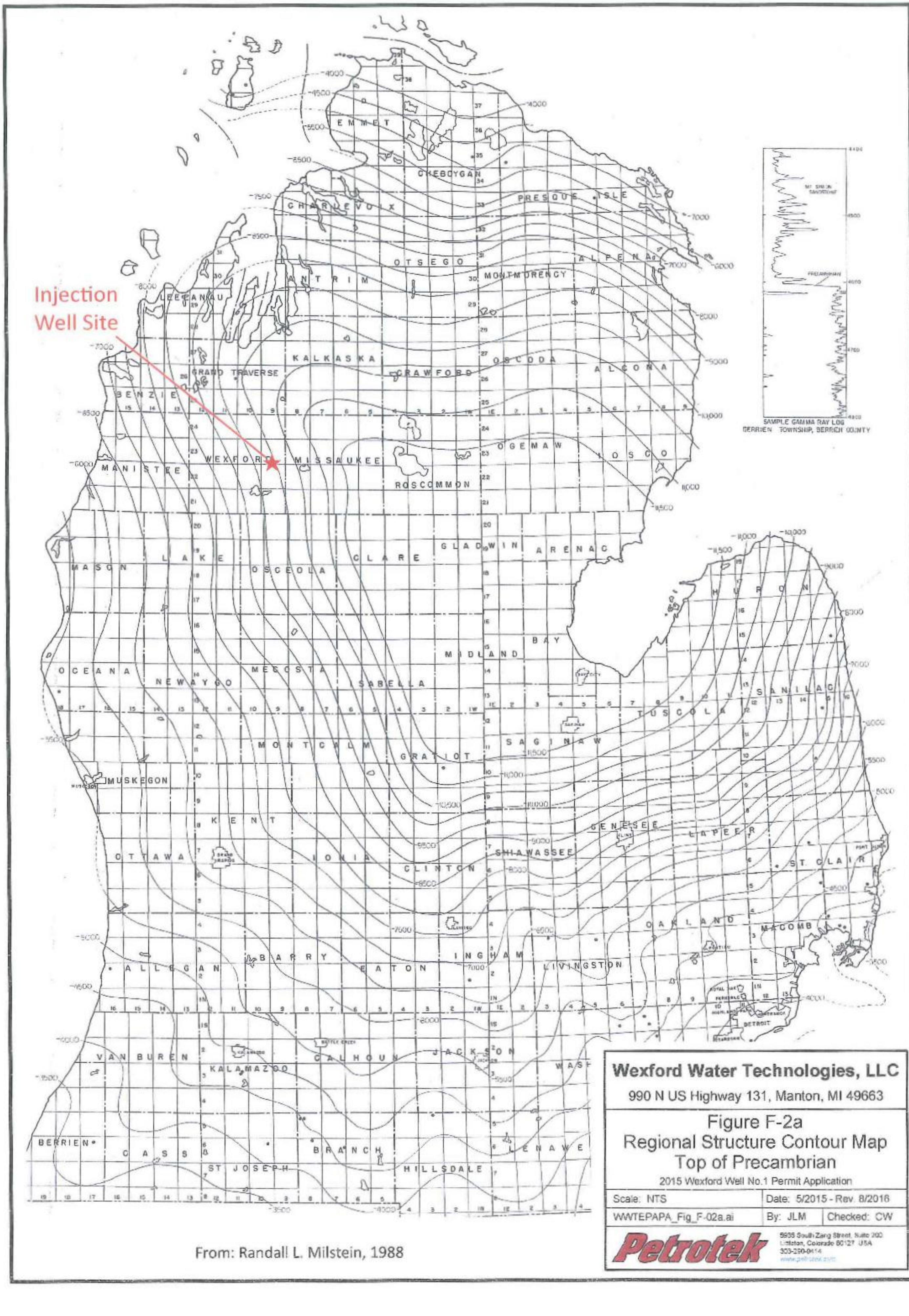

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Figure F-2a
Regional Structure Contour Map
Top of Precambrian

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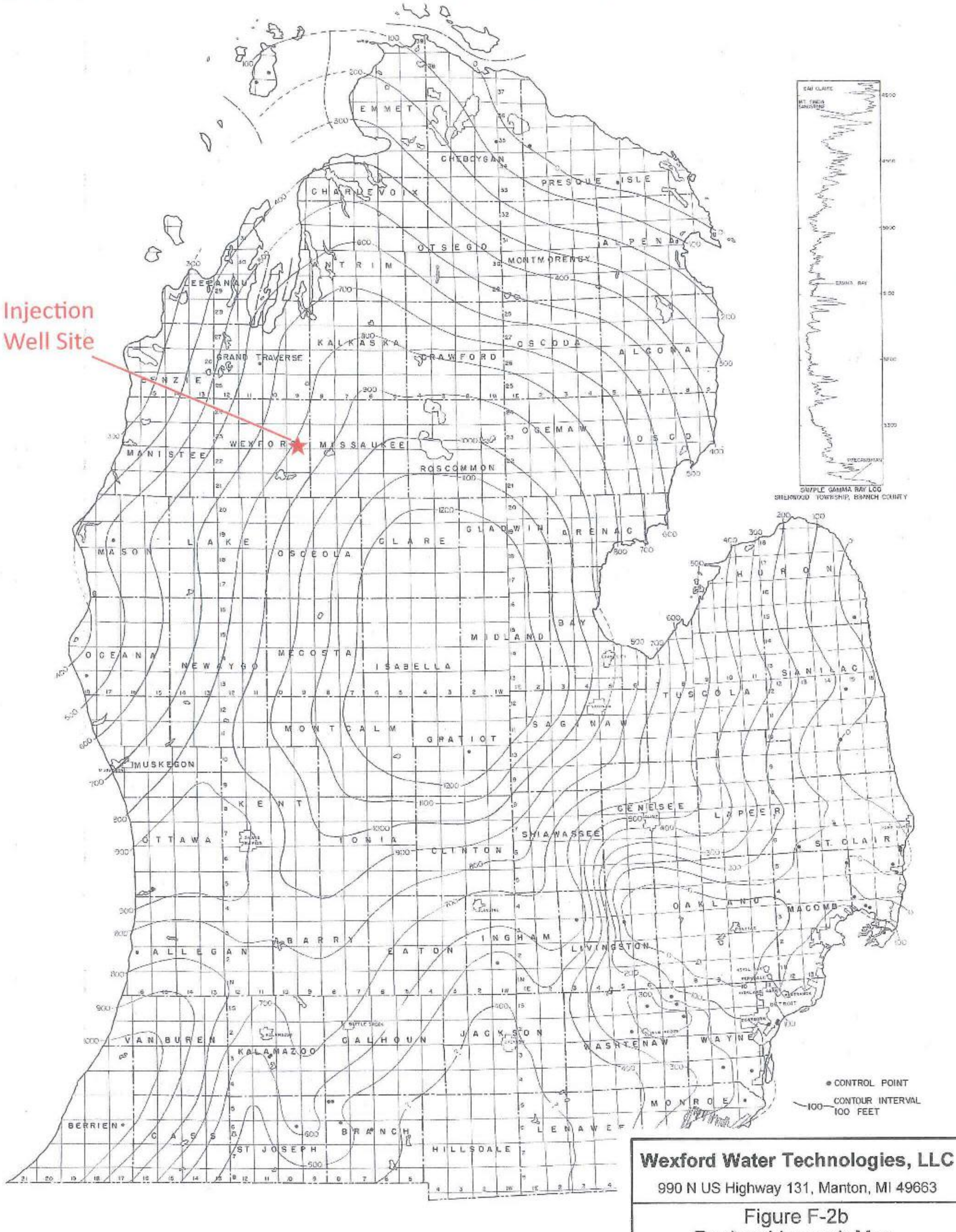

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Figure F-2b
Regional Isopach Map,
Mt. Simon Formation

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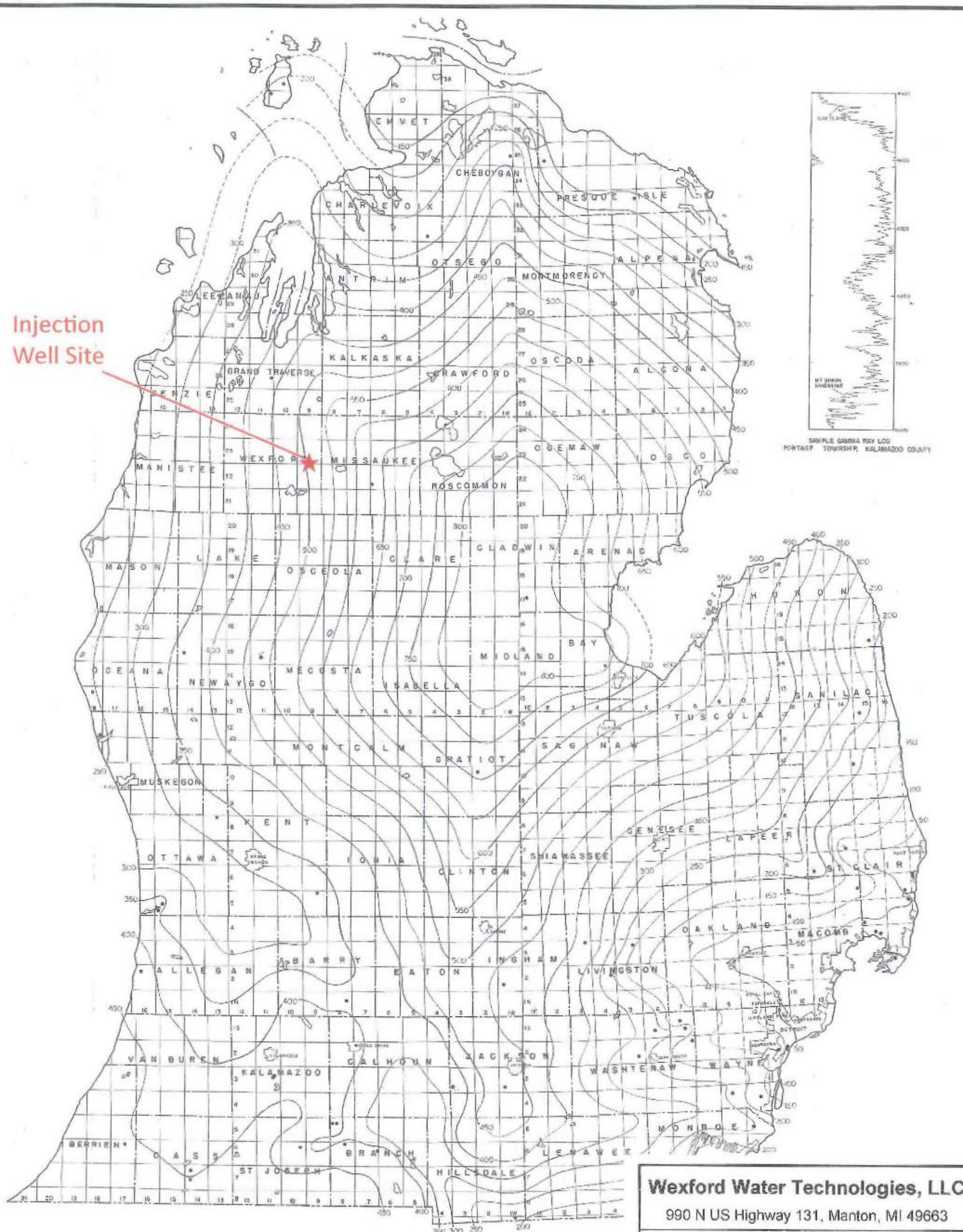

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Figure F-2c
Regional Isopach Map,
Eau Claire Formation

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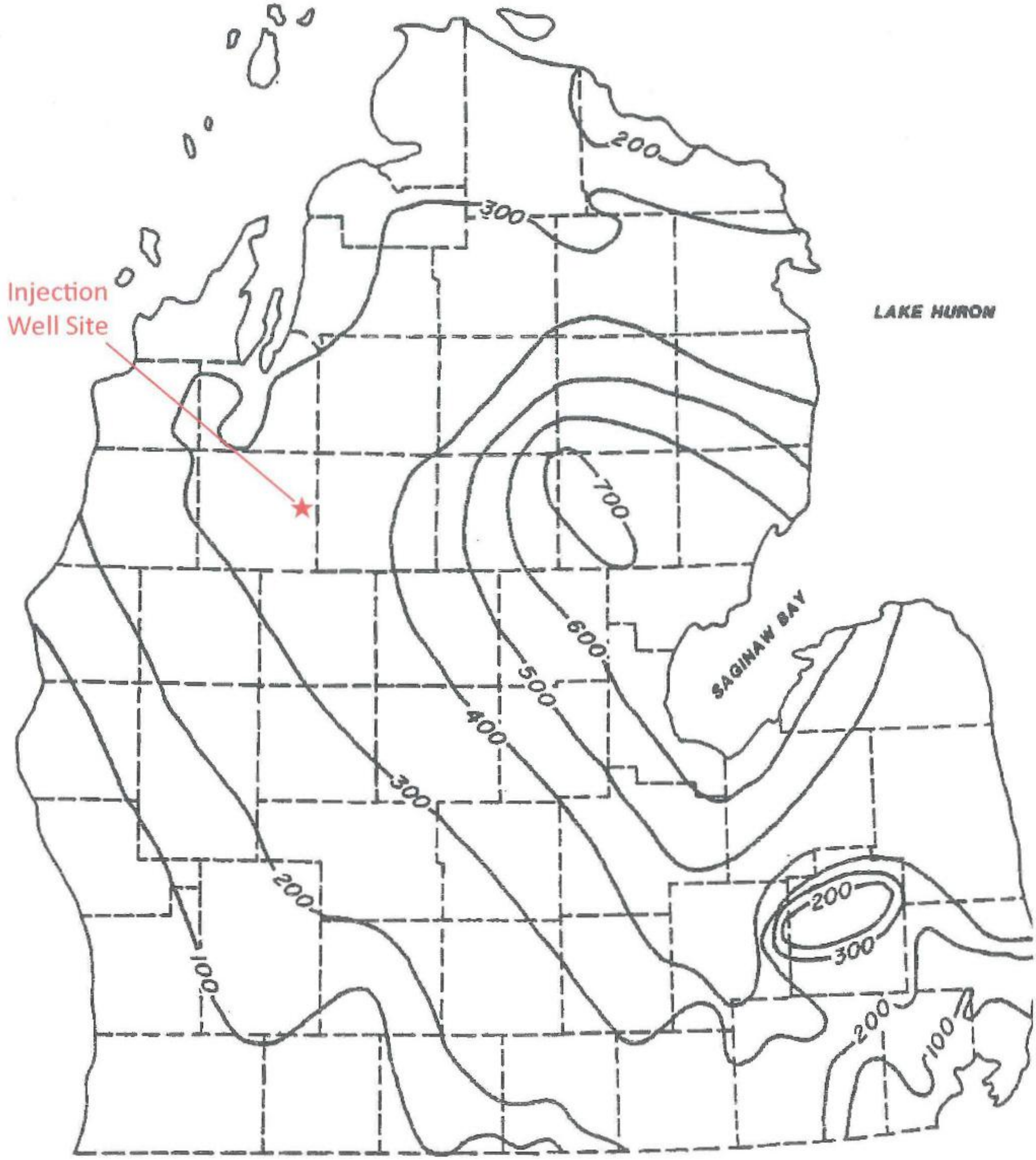

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Figure F-3
Regional Isopach Map,
Bass Islands Formation

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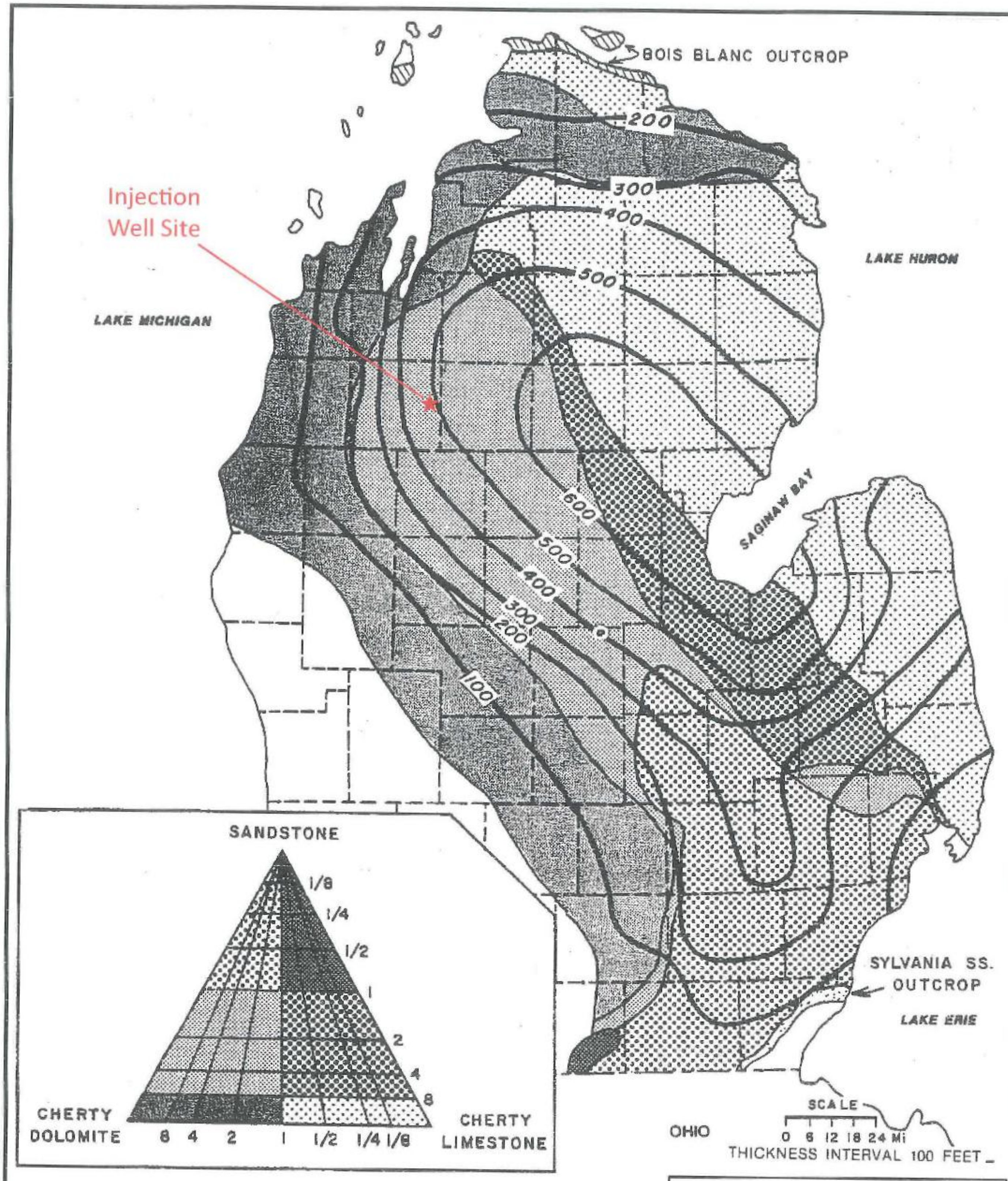

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Figure F-4
Regional Isopach Map,
Bois Blanc Formation

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From: Gardner, 1974

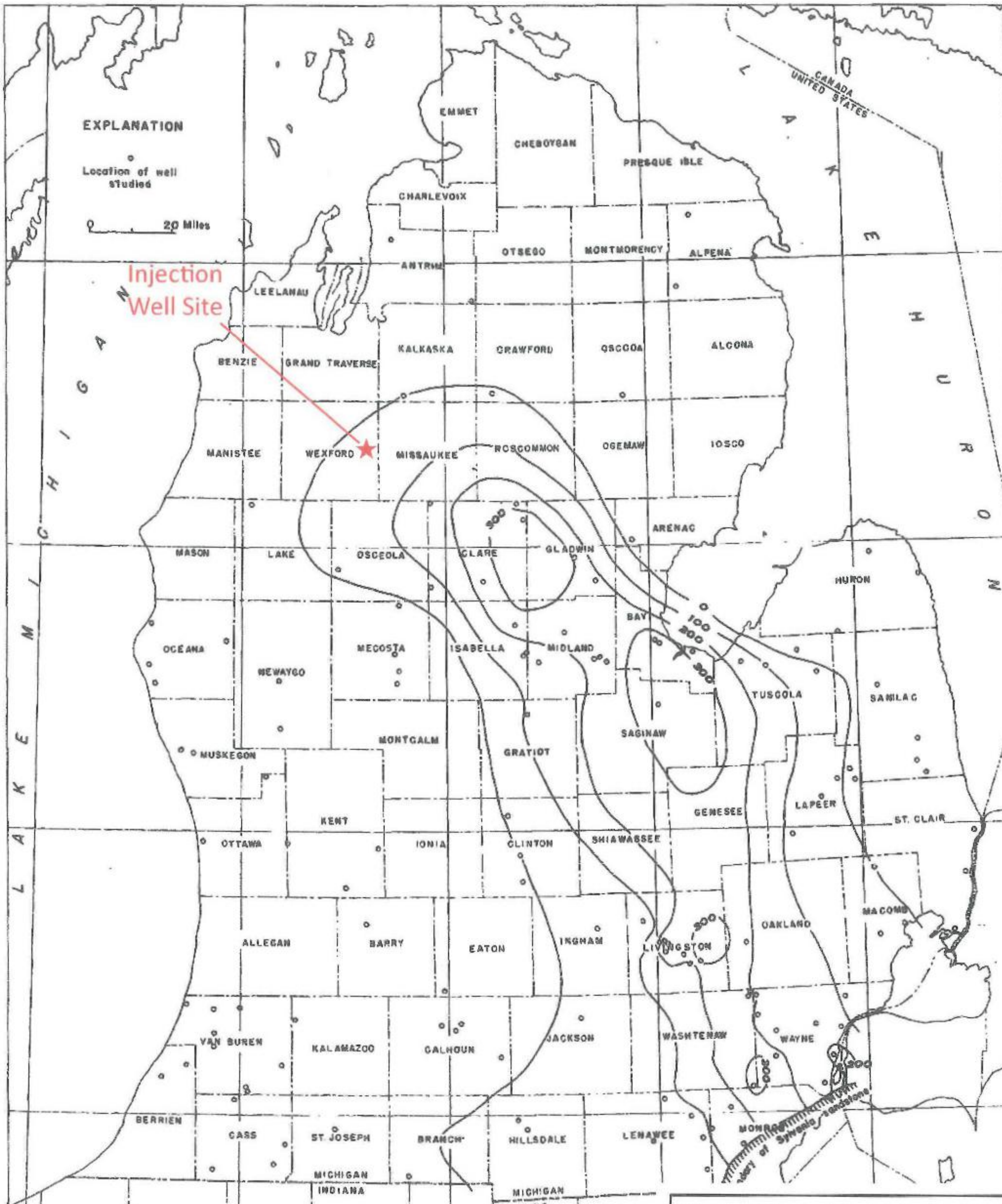

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Figure F-5
Regional Isopach Map,
Sylvania Sandstone

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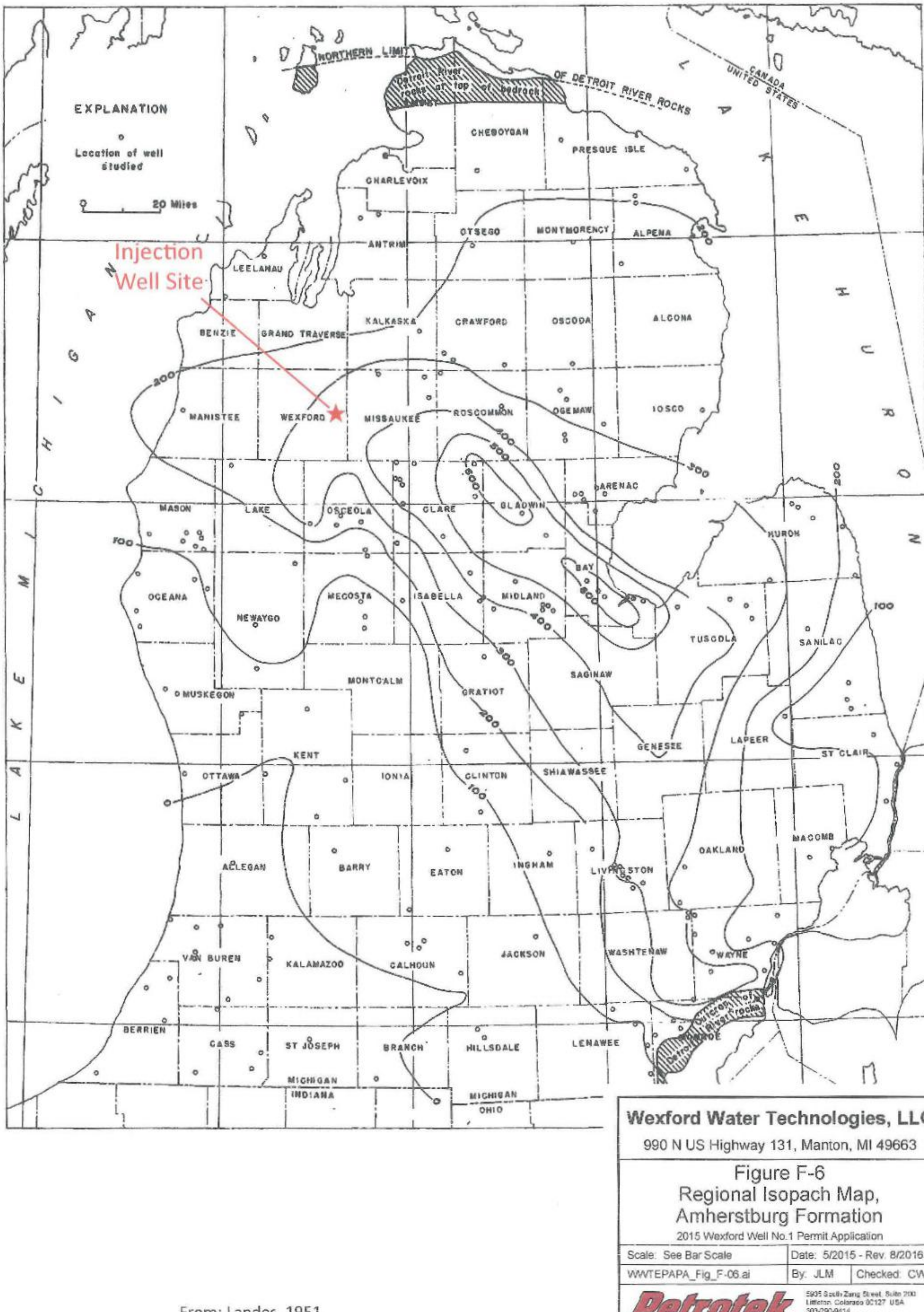

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Figure F-6
Regional Isopach Map,
Amherstburg Formation

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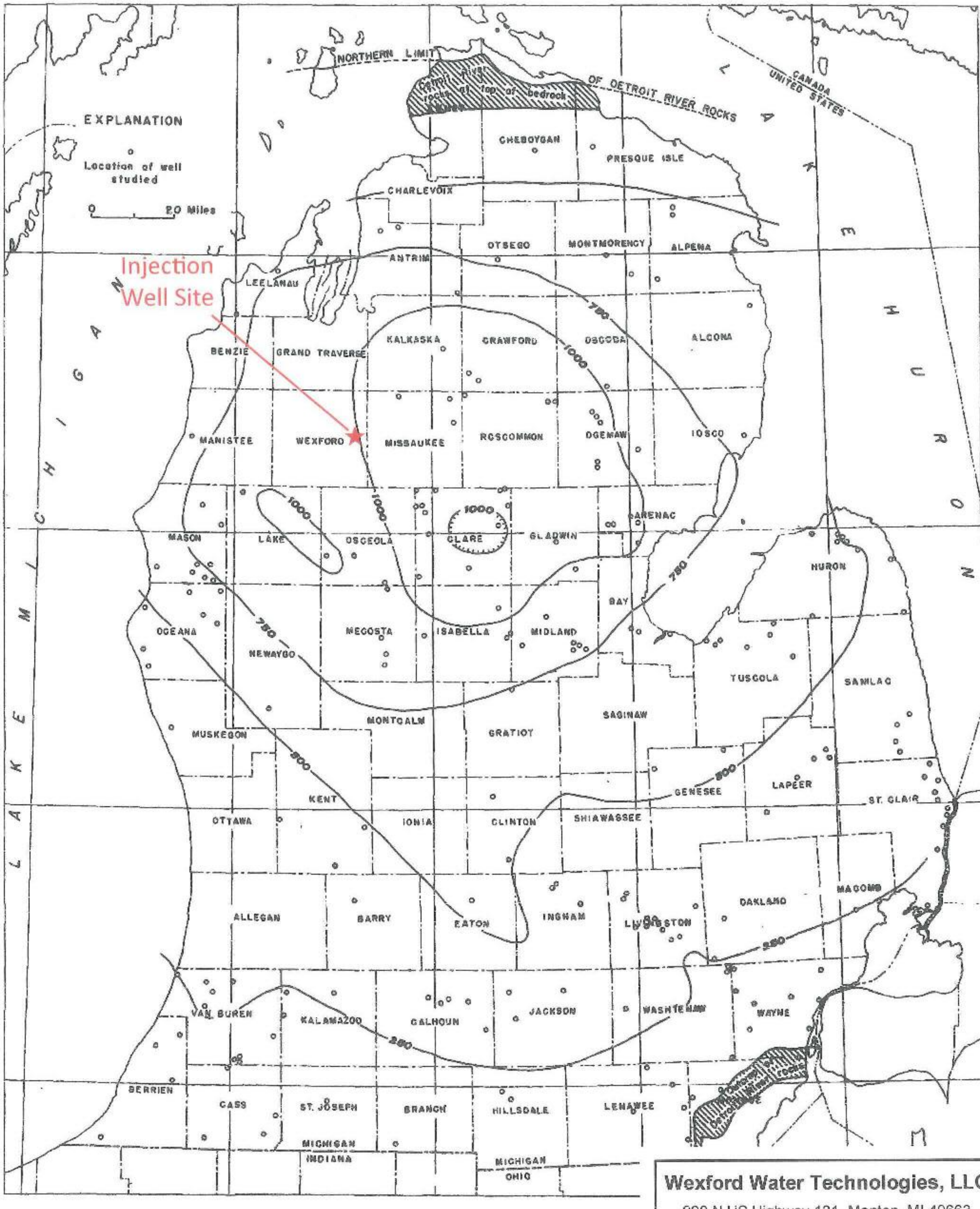

From: Landes, 1951

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Figure F-7
Regional Isopach Map,
Detroit River Group (Lucas Member)

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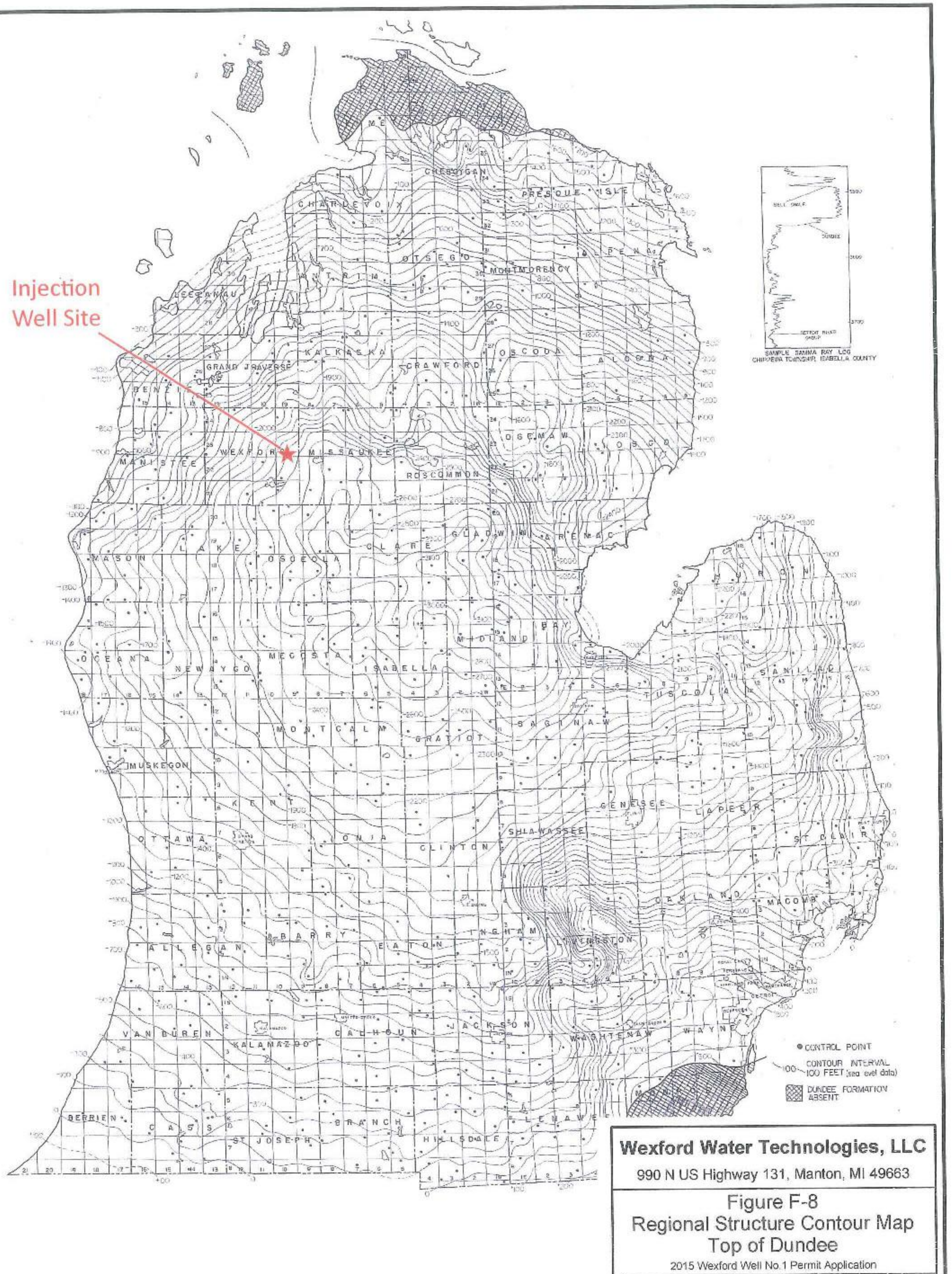

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Figure F-8
Regional Structure Contour Map
Top of Dundee

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-08.ai	By: JLM / Checked: CW

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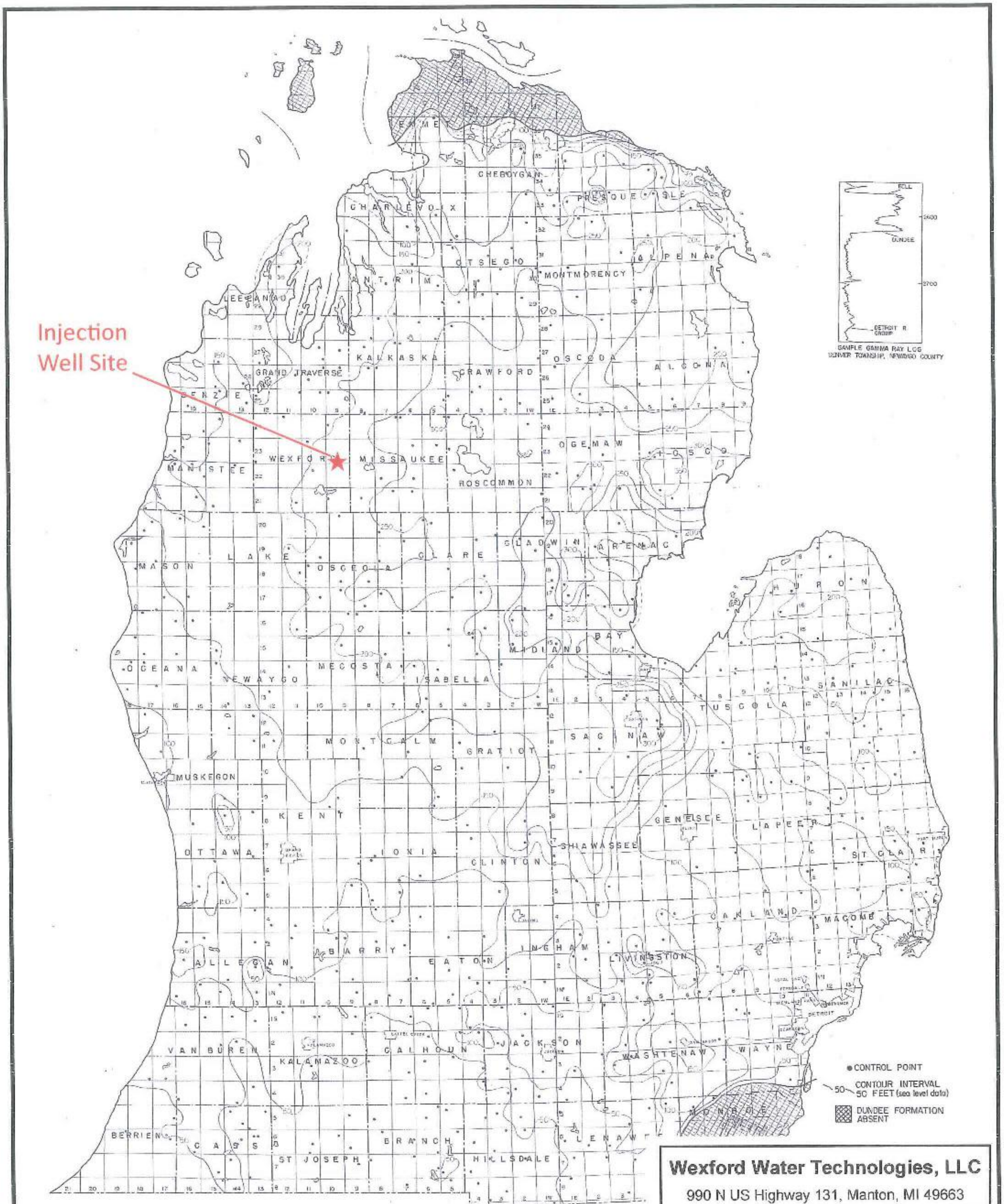
From: Randall L. Milstein, 1985



From: Randall L. Milstein, 1985

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Figure F-9
Regional Isopach Map,
Dundee Formation

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-09.ai	By: JLM / Checked: CW

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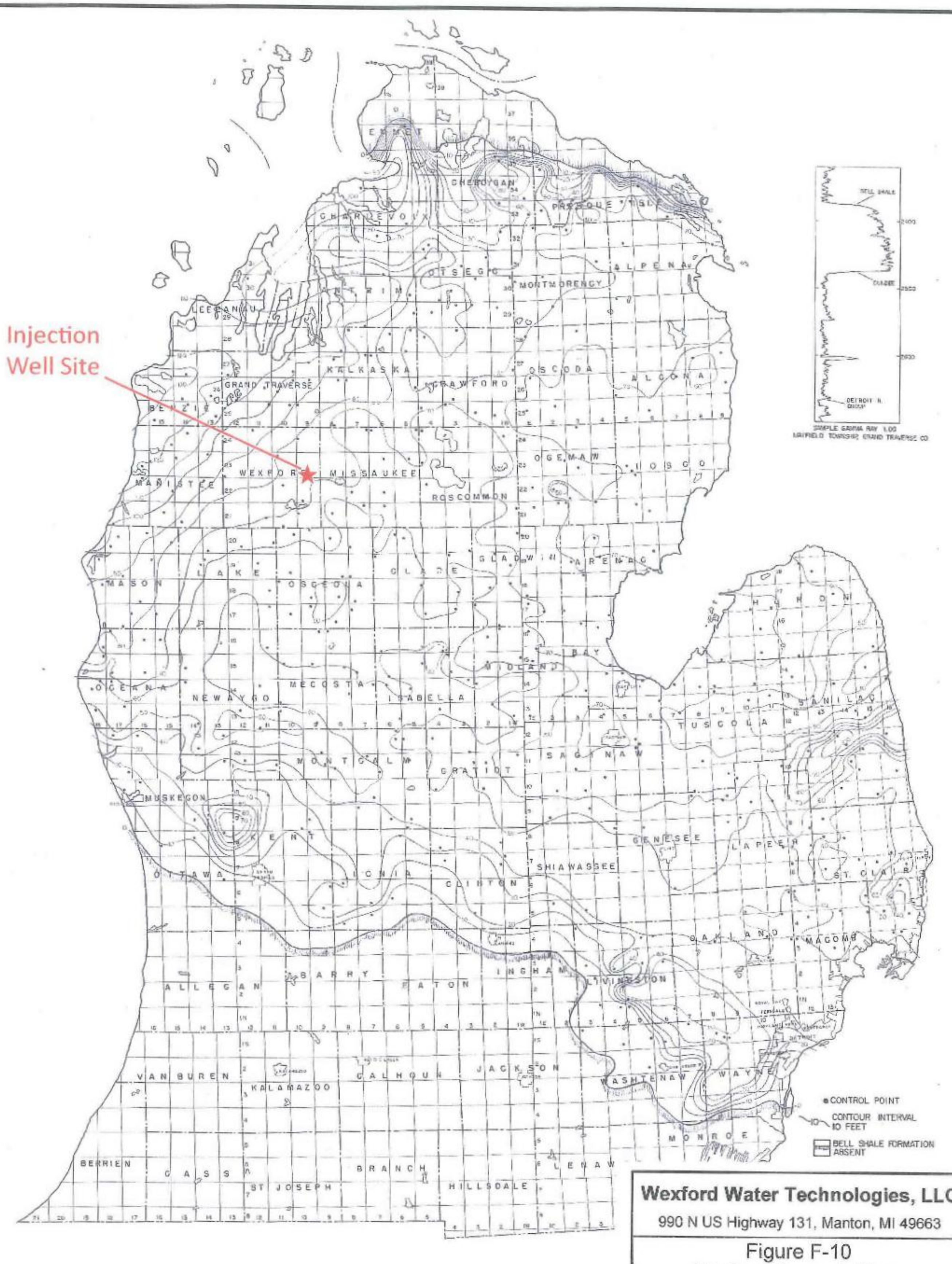

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Figure F-10
Regional Isopach Map,
Bell Shale

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-10.ai	By: JLM	Checked: CW

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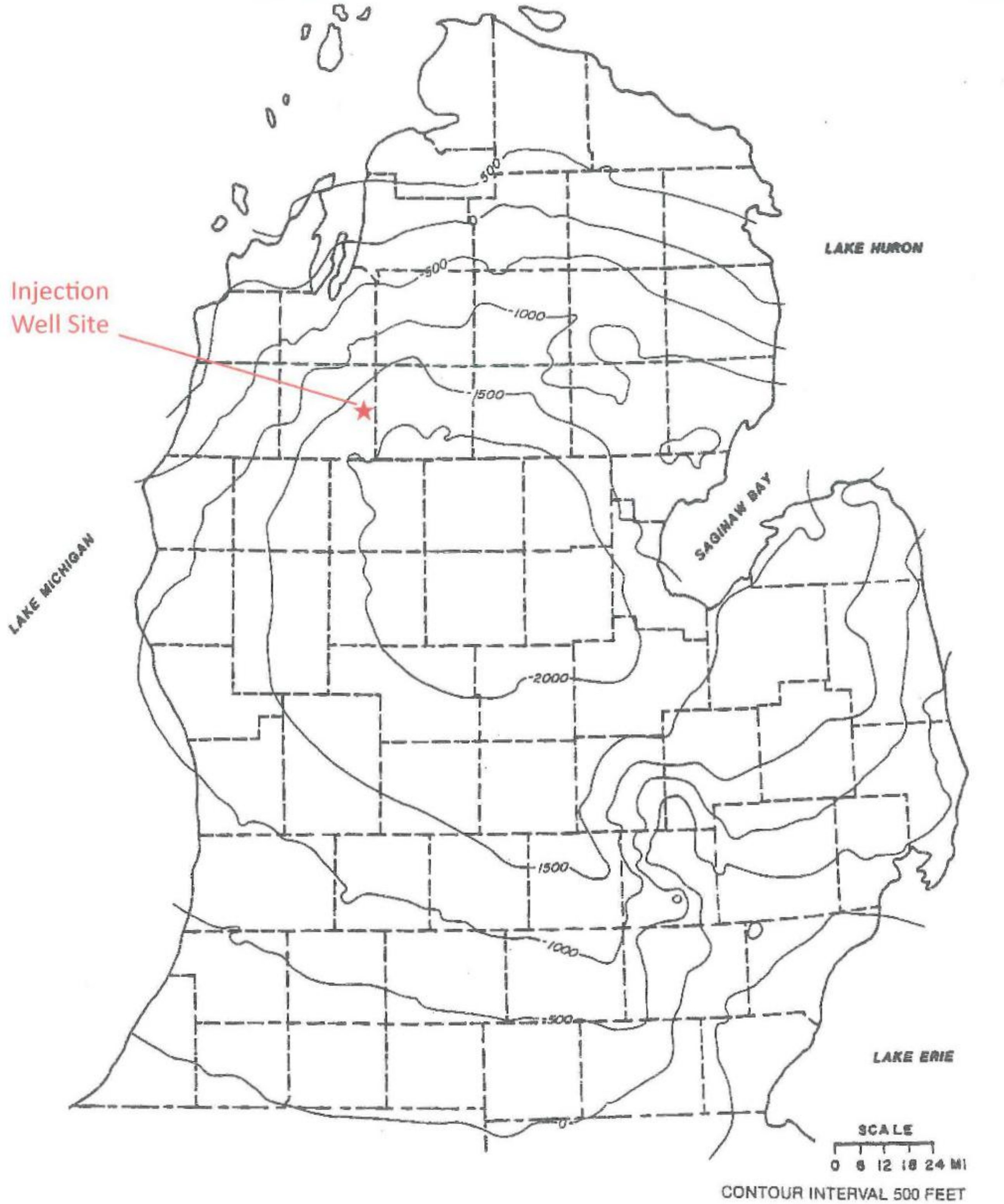

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Figure F-11
Regional Structure Contour Map
Top of Traverse Group

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-11.ai	By: JLM	Checked: CW

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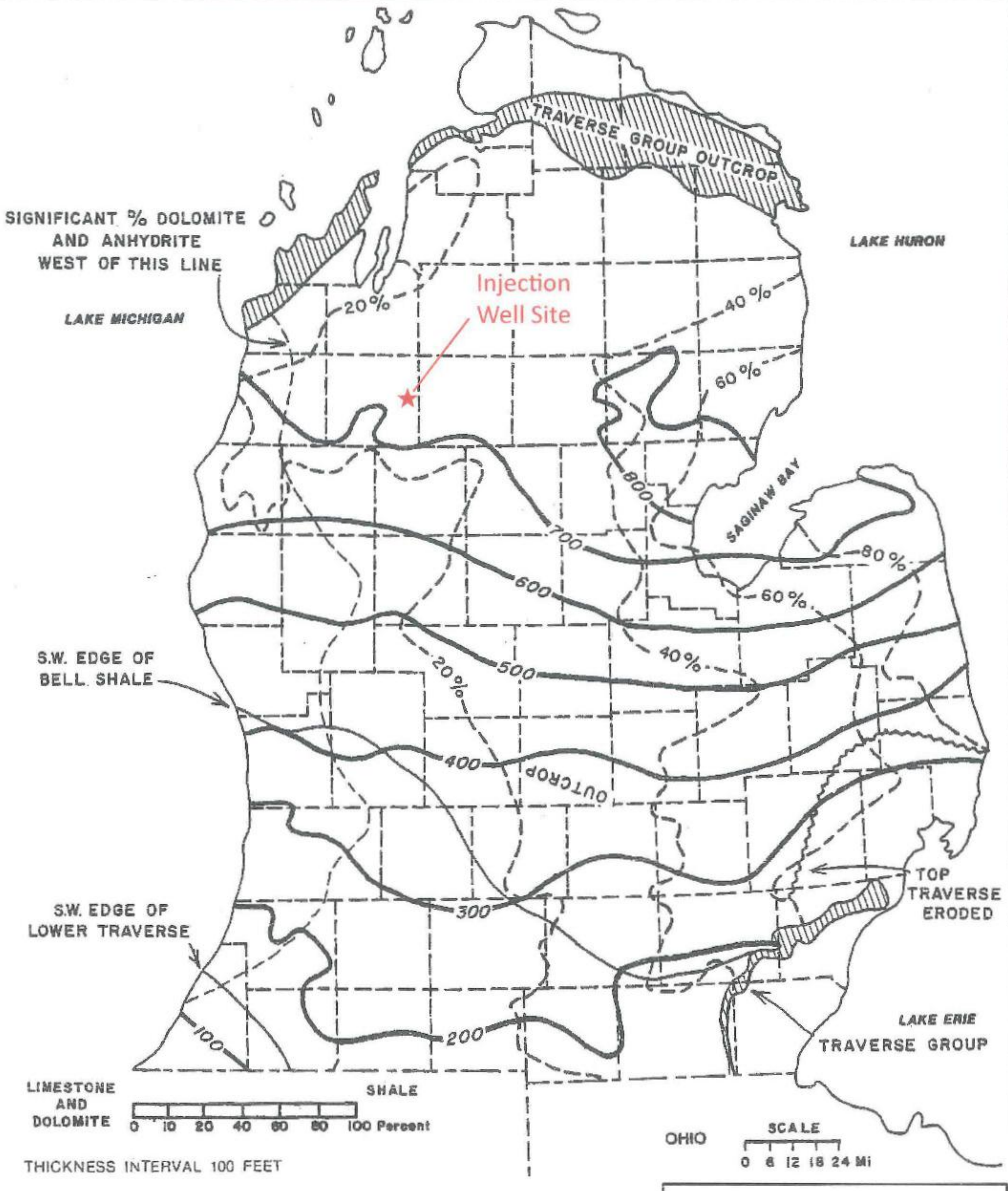
From: Fisher, 1980



From: Gardner, 1974

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Figure F-12
Regional Isopach Map,
Traverse Group

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-12.ai	By: JLM · Checked: CW

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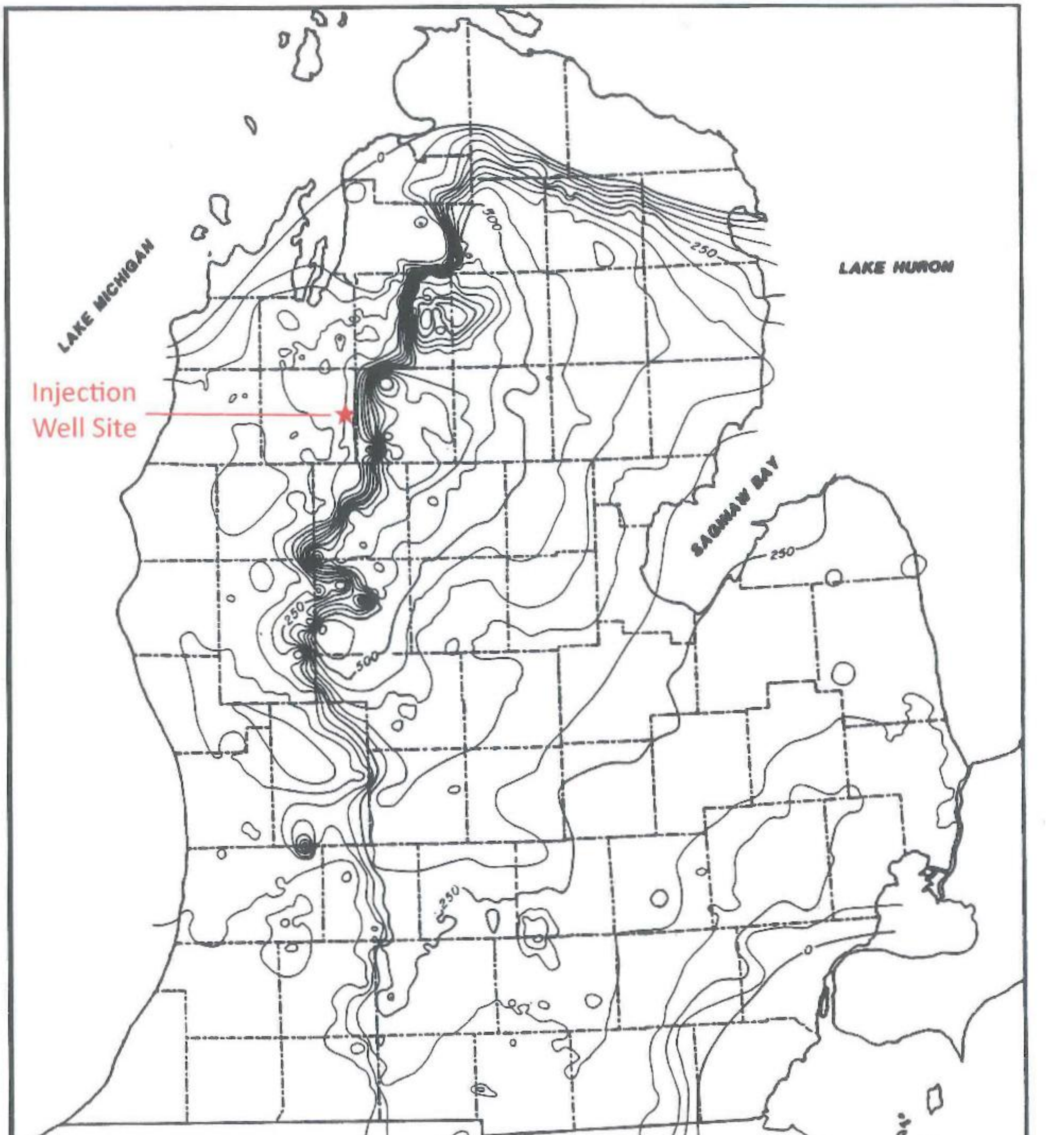

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Figure F-13
Regional Isopach Map,
Antrim Formation

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-13.ai	By: JLM	Checked: CW

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From: Fisher, 1980

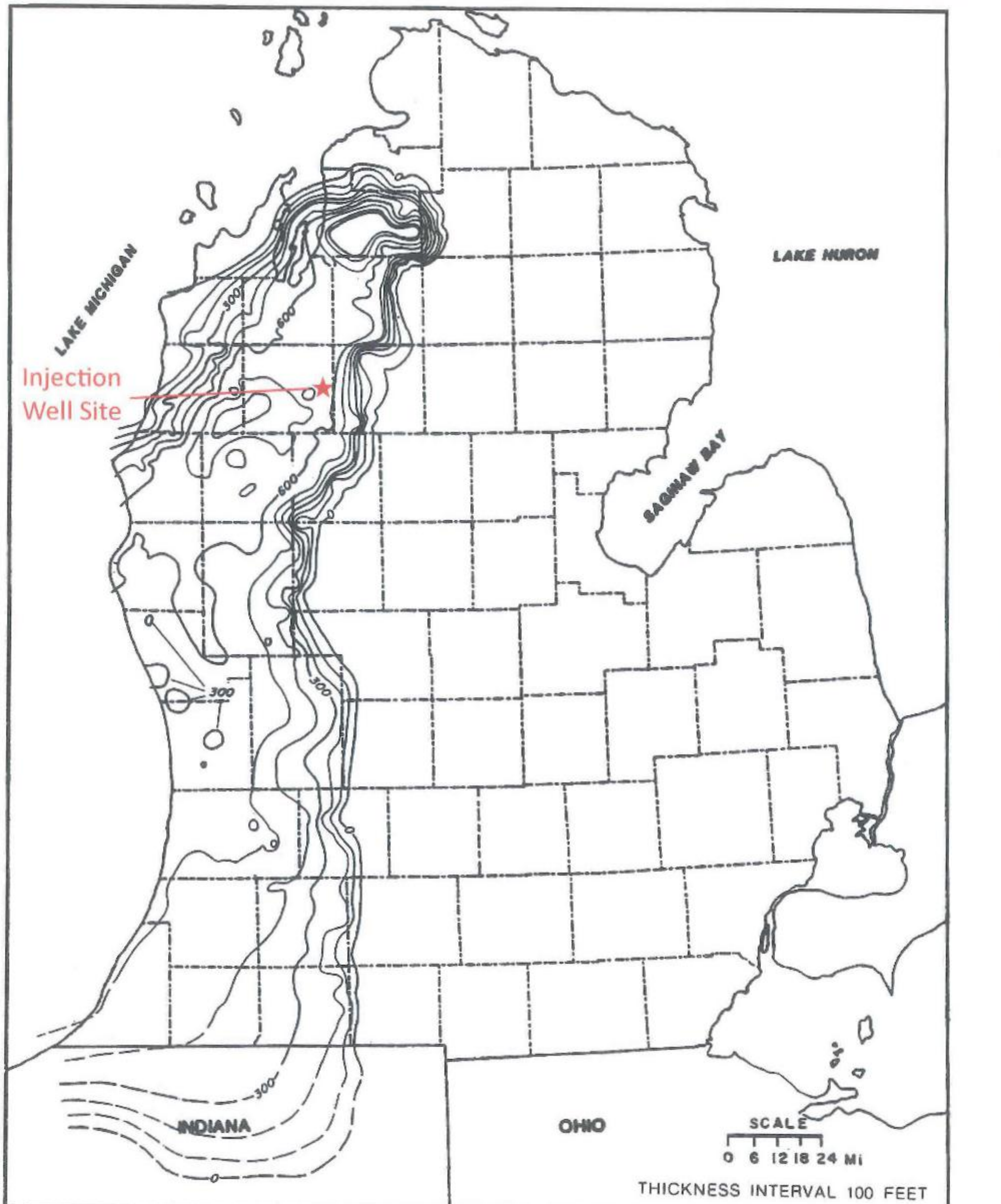

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Figure F-14
Regional Isopach Map,
Ellsworth Shale

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-14.ai	By: JLM	Checked: CW

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From: Fisher, 1980

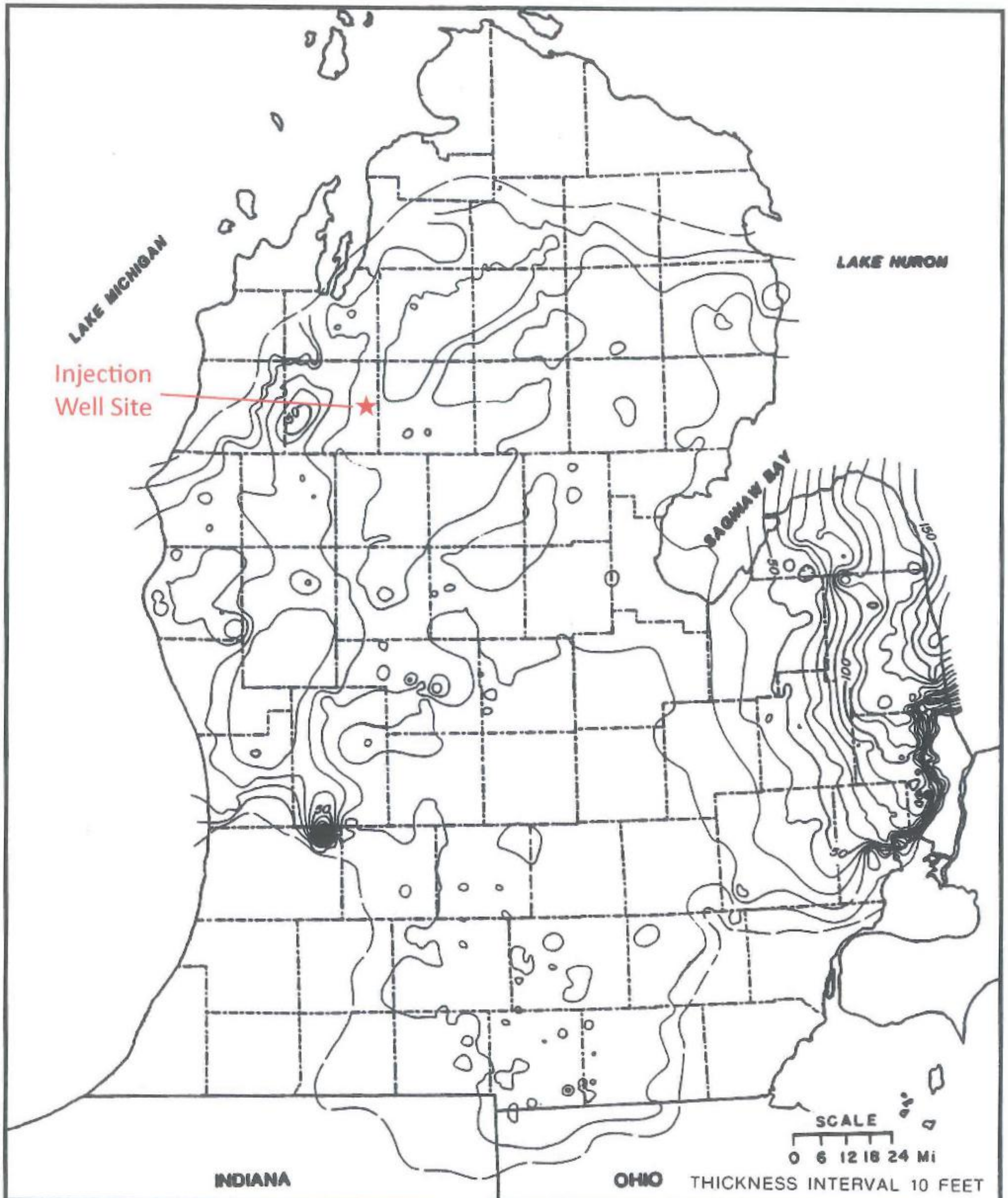

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Figure F-15
Regional Isopach Map,
Sunbury Shale

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-15.ai	By: JLM	Checked: CW

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From: Fisher, 1980

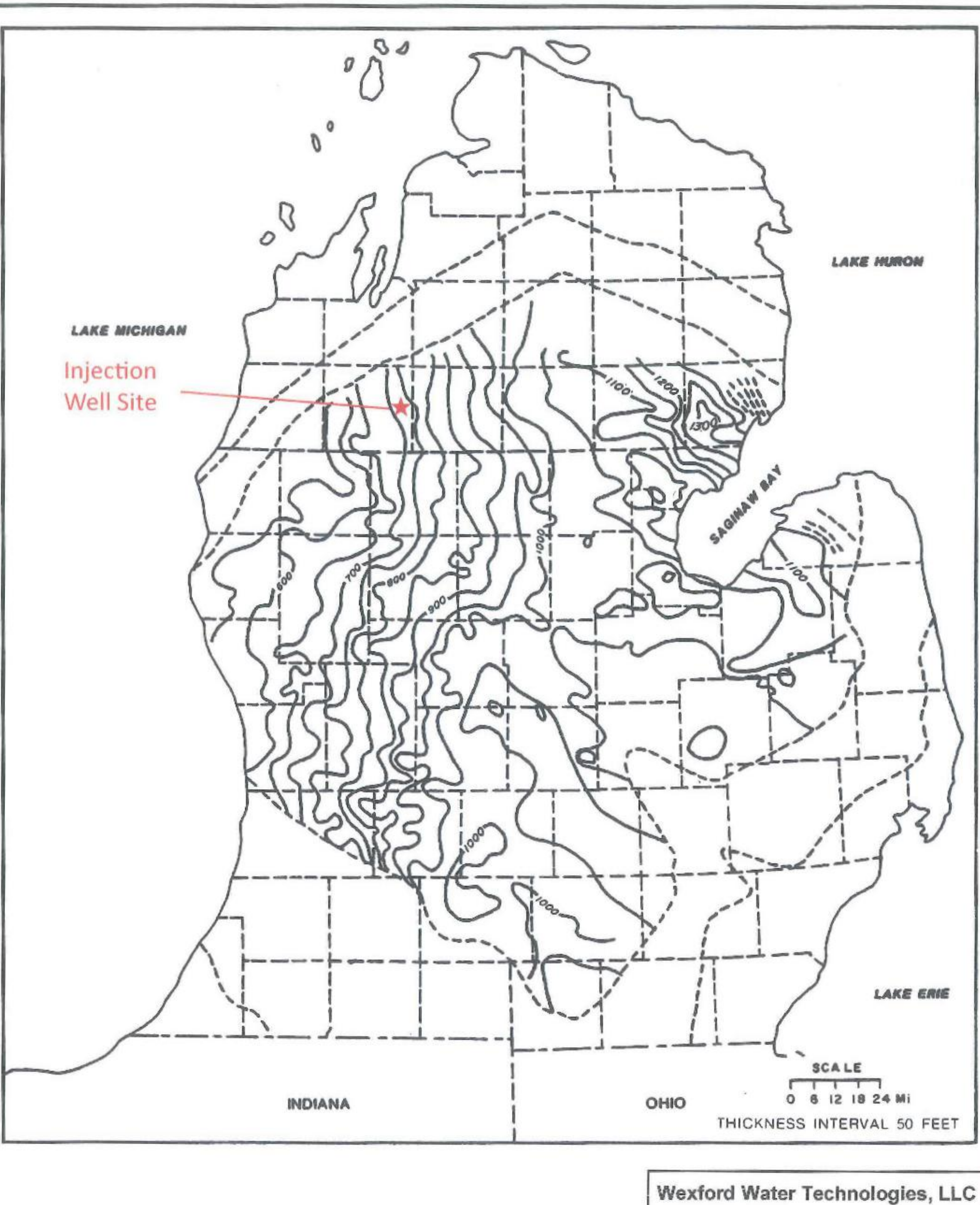

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Figure F-16
Regional Isopach Map,
Coldwater Shale

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-16.si	By: JLM · Checked: CW

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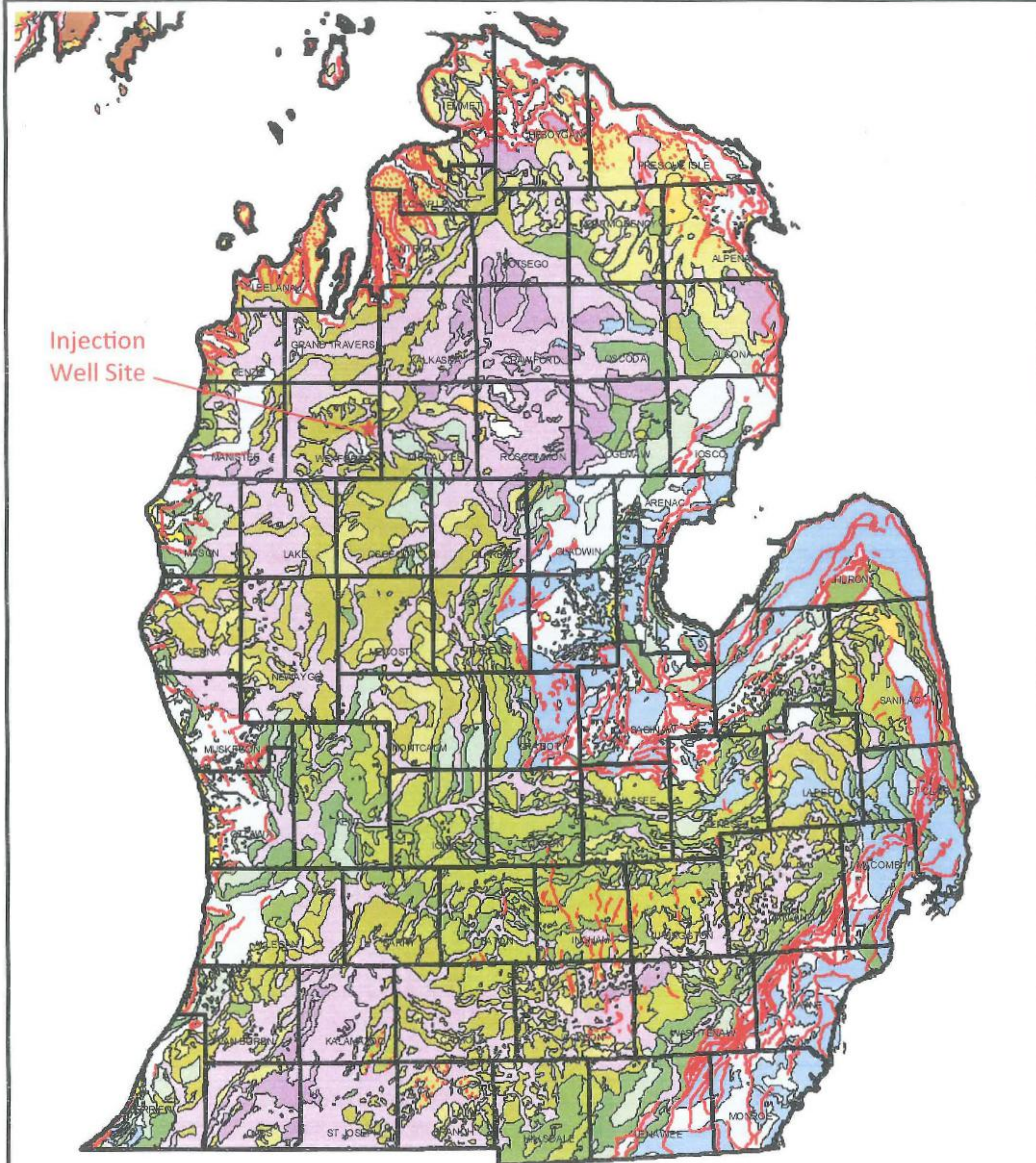
From: Chung, 1973



QUATERNARY GEOLOGY OF MICHIGAN

- Peat and muck
- Postglacial alluvium
- Dune sand
- Lacustrine clay and silt
- Lacustrine sand and gravel
- Glacial outwash sand and gravel and postglacial alluvium
- Ice-contact outwash sand and gravel
- Fine-textured glacial till
- End moraines of fine-textured till
- Medium-textured glacial till
- End moraines of medium-textured till
- Coarse-textured glacial till
- End moraines of coarse-textured till
- Thin to discontinuous glacial till over bedrock
- Artificial fill
- Exposed bedrock surfaces
- Water

- Drumlins
- Eskers
- Shorelines
- Sinkholes
- Striations/Grooves

From: Michigan DNR, 1982

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Figure F-17
Regional Surface Geology Map

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-17.ai	By: JLM / Checked: CW

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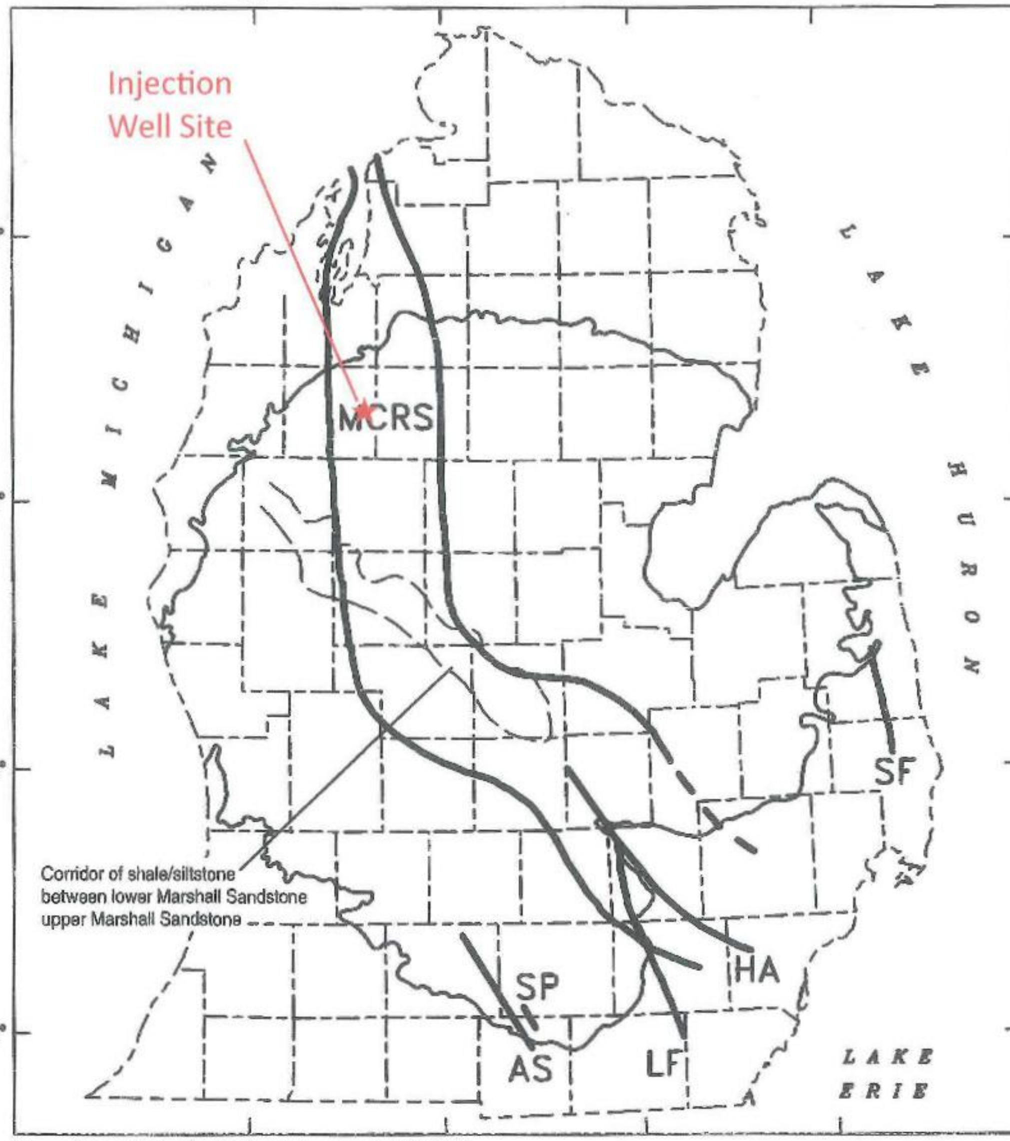

Base from U.S. Geological Survey 1:500,000 state base map, 1970

0 20 40 60 MILES

0 20 40 60 KILOMETERS

EXPLANATION

MCRS MIDCONTINENT RIFT SYSTEM, DASHED WHERE APPROXIMATELY LOCATED

HA HOWELL ANTICLINE

SP STONY POINT FAULT

LF LUCAS FAULT

AS ALBION SCIPIO TREND

SF SANILAC FAULT

Modified from: Budai, Wilson, 1991 & Fisher, 1981

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Figure F-18
Regional Structure Features,
Michigan Basin

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-18.ai	By: JLM / Checked: CW

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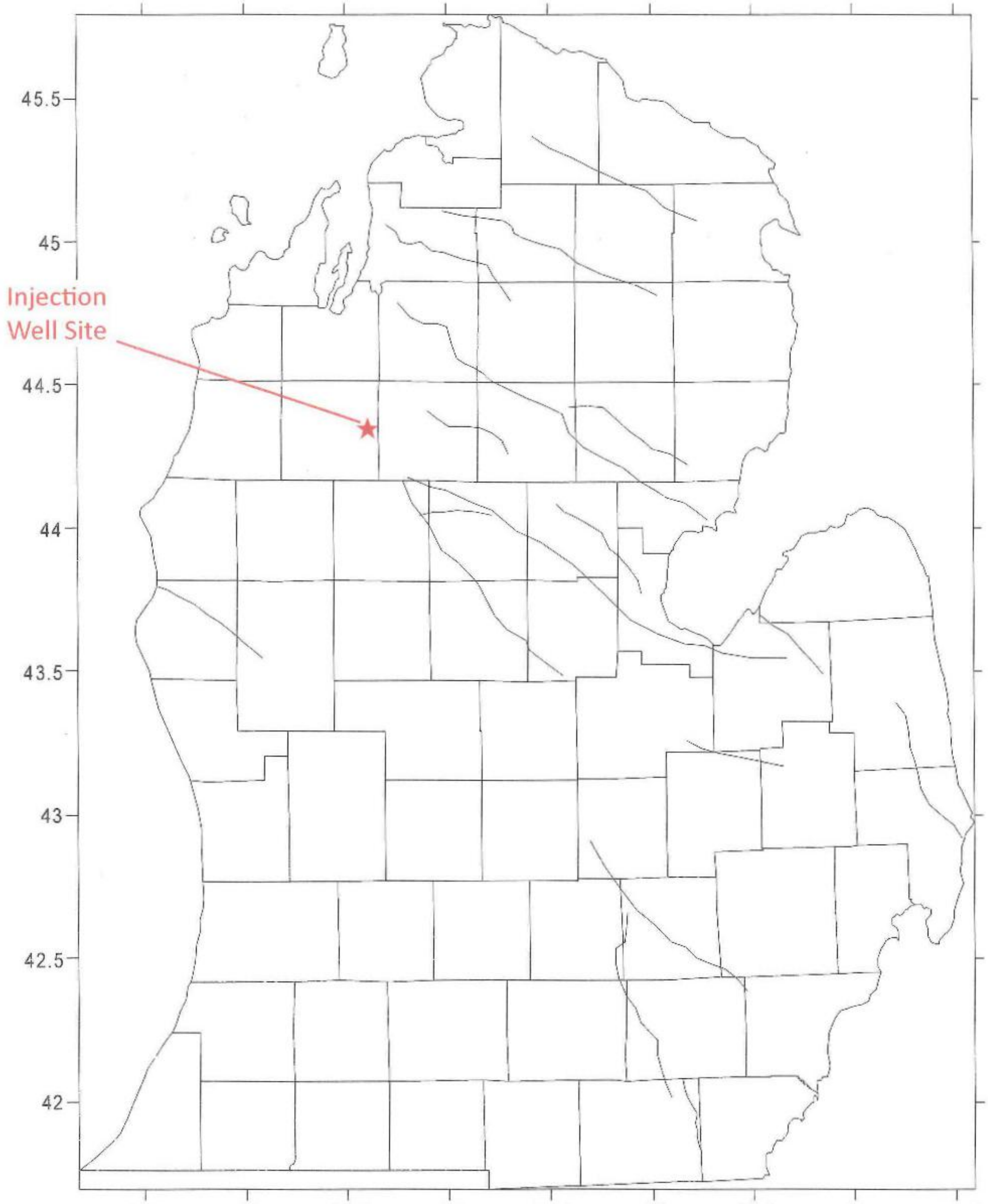

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Figure F-19
Regional Fault or Lineaments,
Michigan Basin

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-19.ai	By: JLM	Checked: CW

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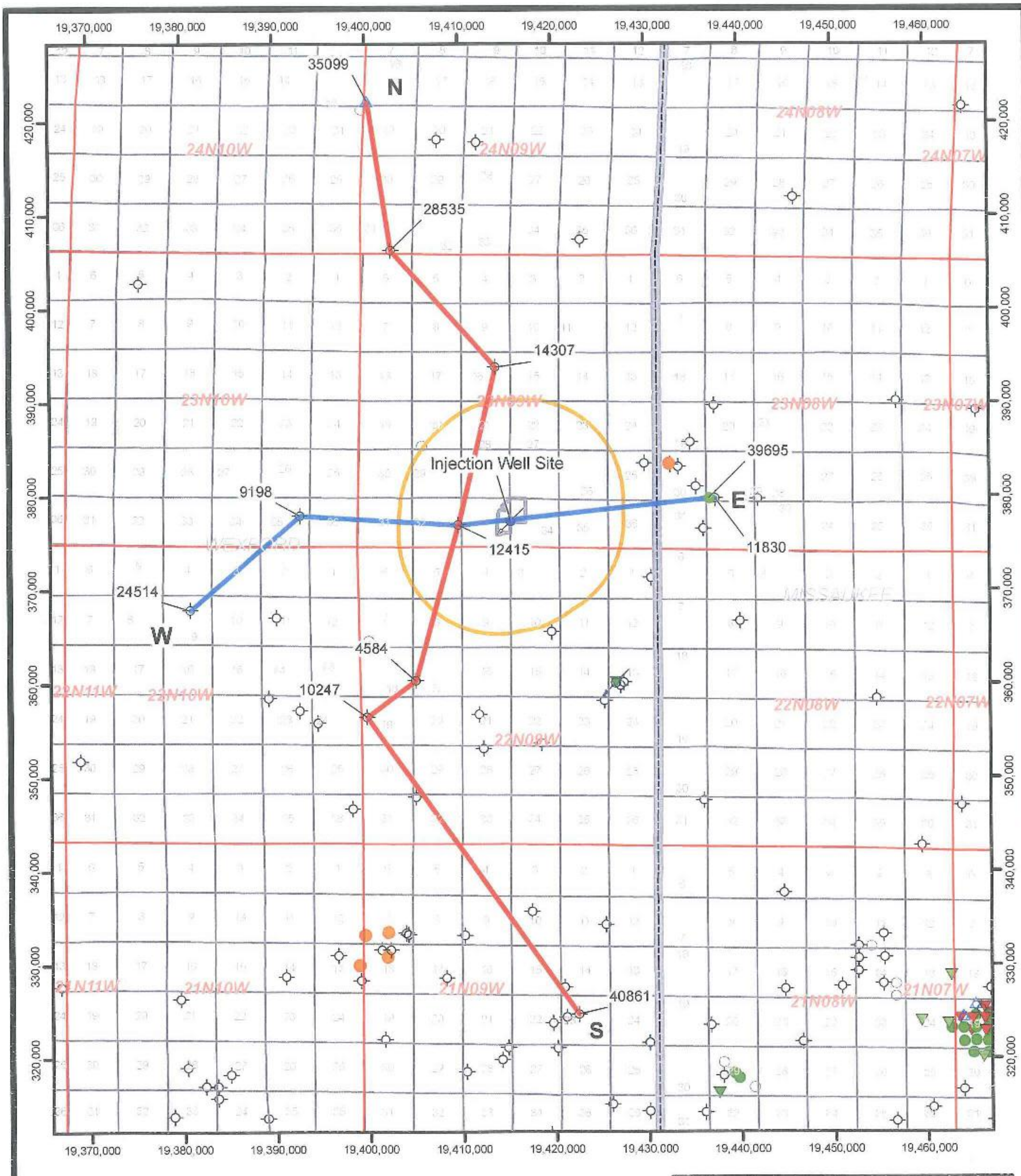
From: Wood & Harrison, 2002



Legend

- Injection Well Site
- N - S Section Line
- W - E Section Line
- Wexford Property Boundary
- 2 Mile AOR

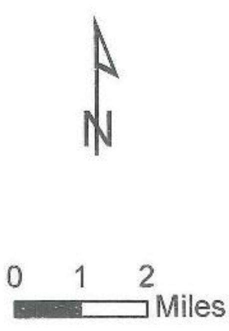


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Figure F-20
Well Location Map
with Cross Section Locations

2015 Wexford Well No.1 Permit Application

Scale: 1:175,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-20.mxd	By: JLM / Checked: CW

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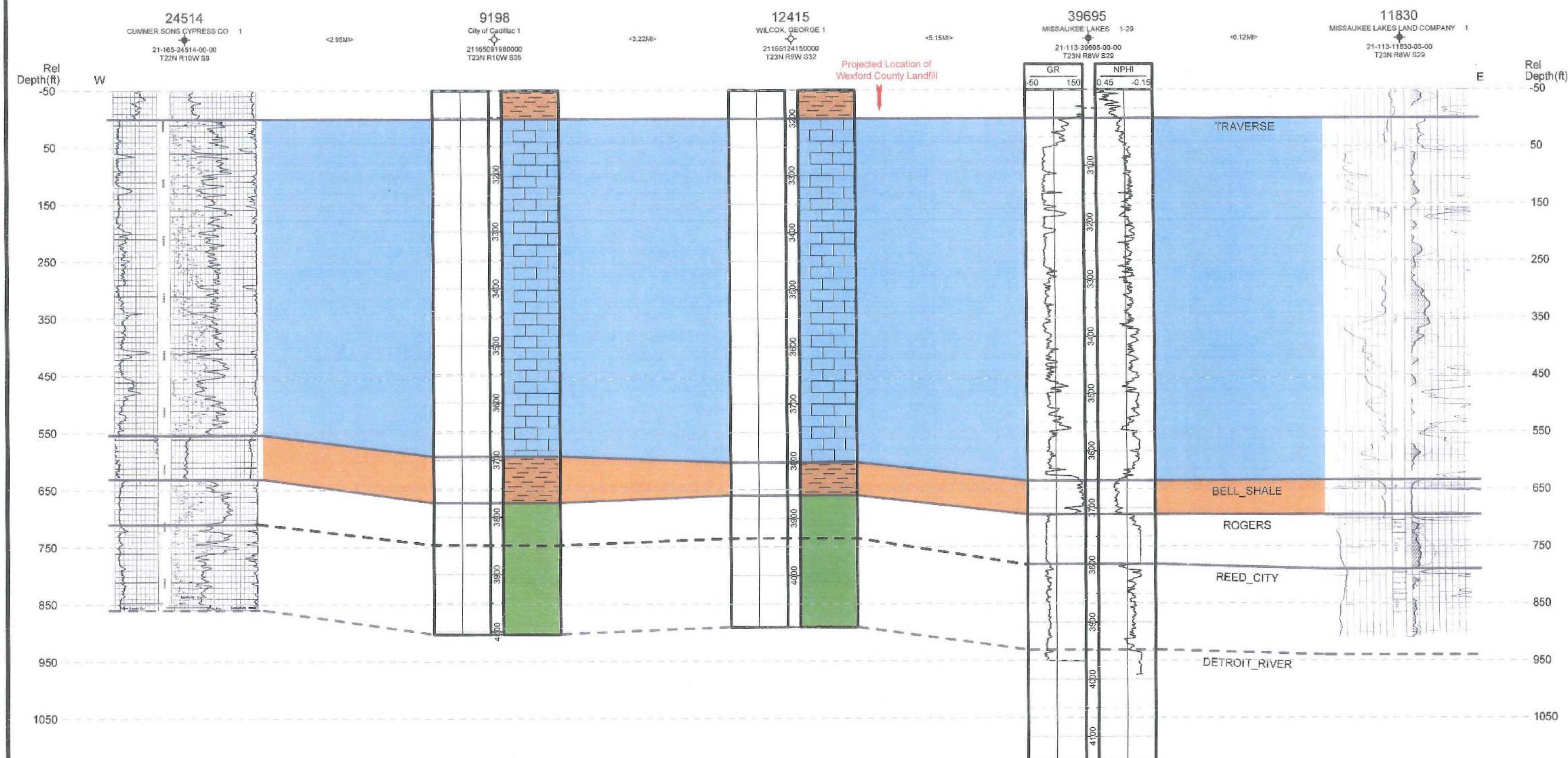

PETRA 4/9/2015 2:01:19 PM (WE traverse and dundee.CSP)

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Figure F-21a Local E-W Cross Section, Traverse - Dundee 2015 Wexford Well No.1 Permit Application		
Scale: NTS	Date: May 2015	
WWTEPAPA_Fig_F-21a.ai	By: JLM	Checked: CW
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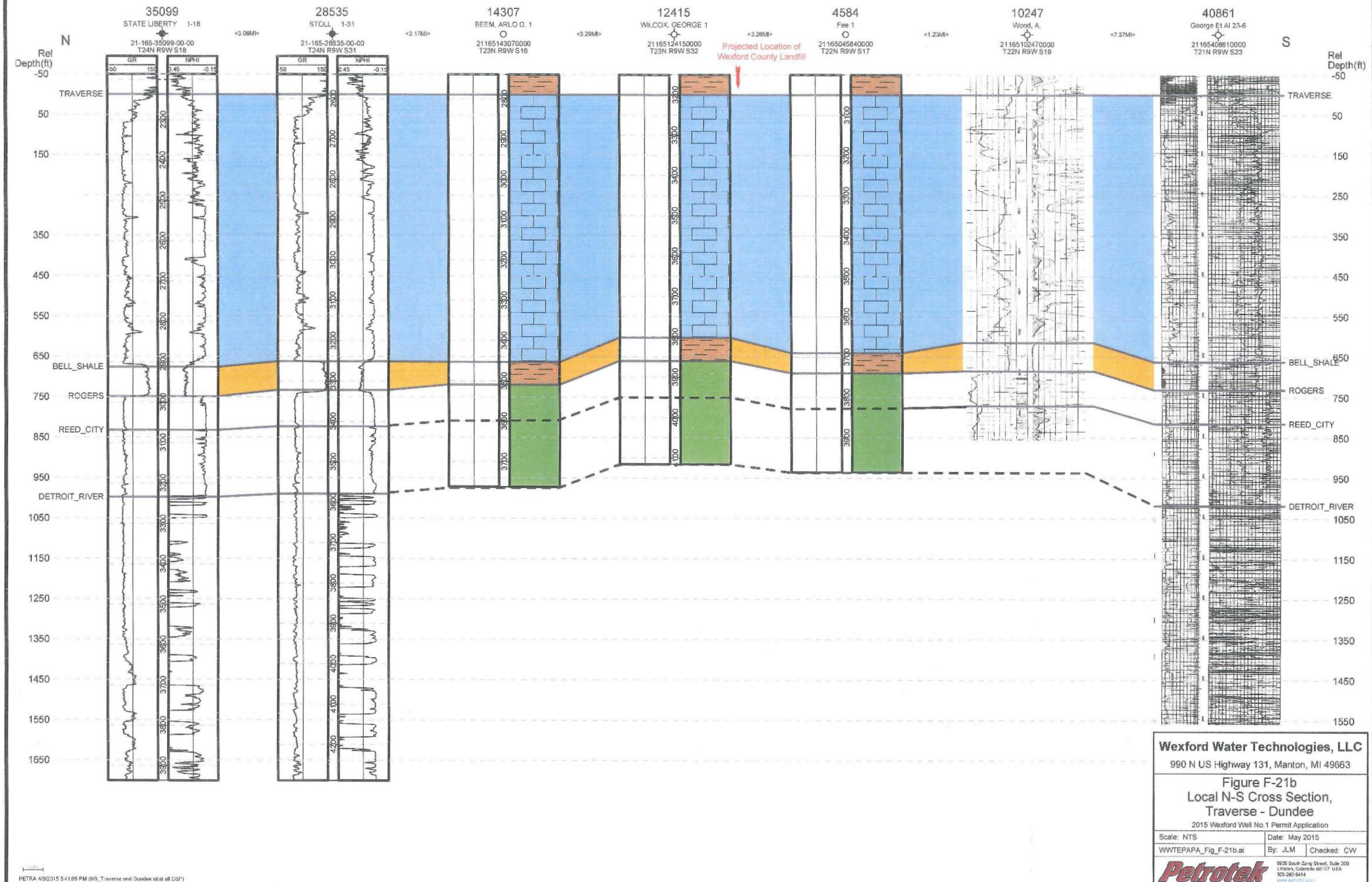

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Figure F-21b
Local N-S Cross Section,
Traverse - Dundee

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: May 2015
WWTEPAPA_Fig_F-21b.ai	By: JLM / Checked: CW

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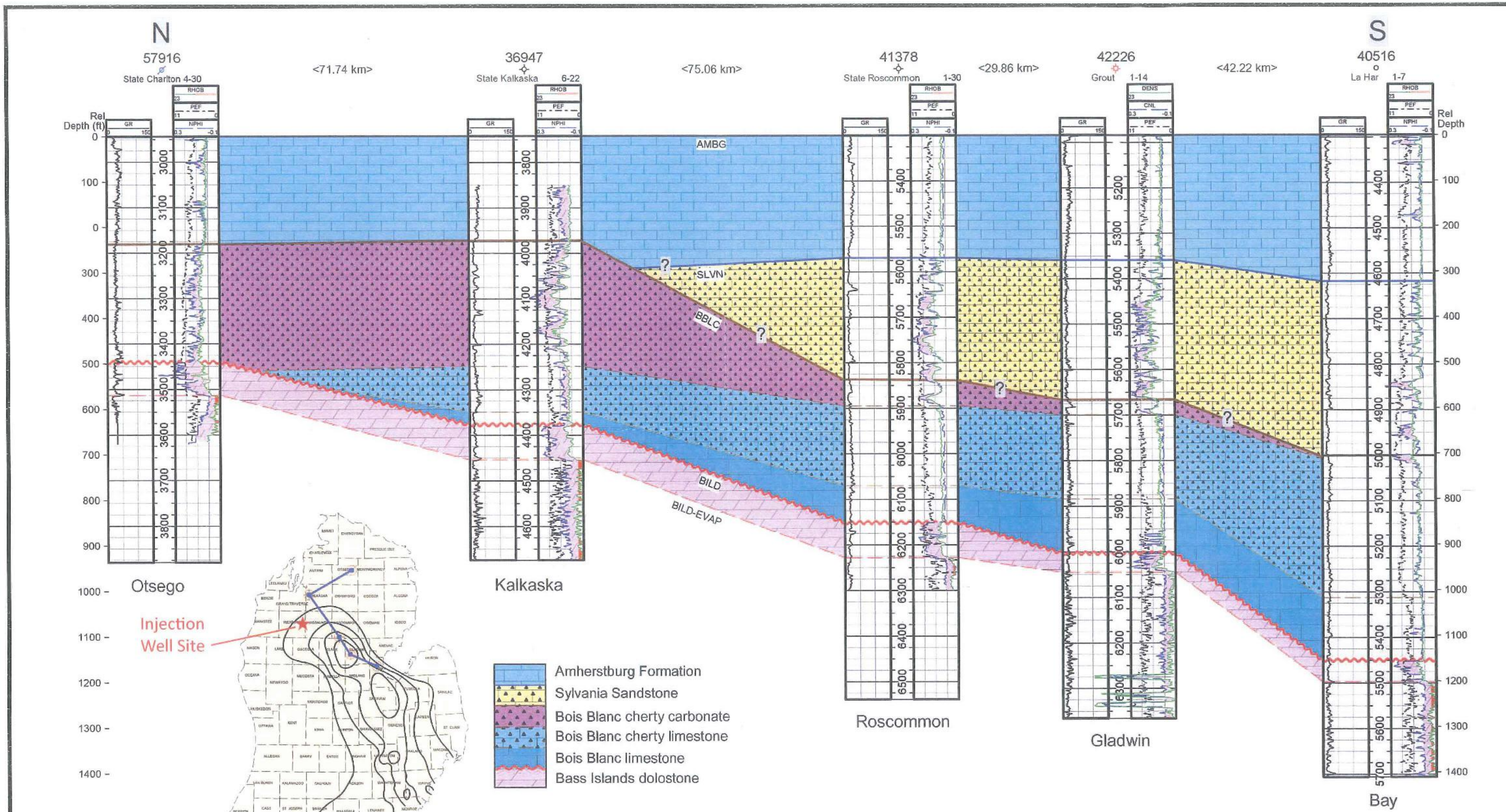

From: Barnes et al., 2009

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Figure F-22a
Regional N-S Cross Section,
Sub Detroit River

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-22a.ai	By: JLM	Checked: CW

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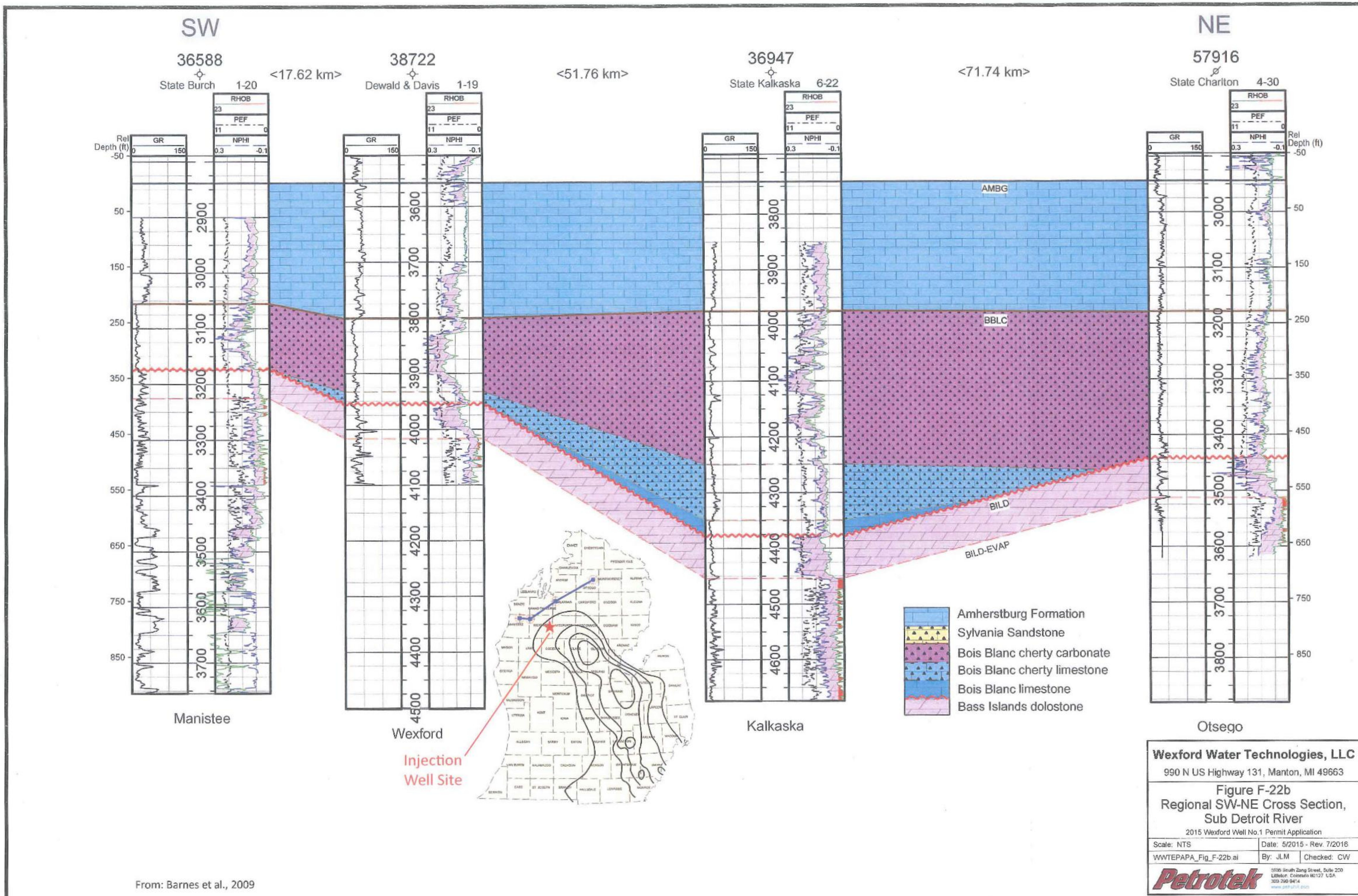

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Figure F-22b
Regional SW-NE Cross Section,
Sub Detroit River

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 7/2016
WWTEPAPA_Fig_F-22b.ai	By: JLM / Checked: CW

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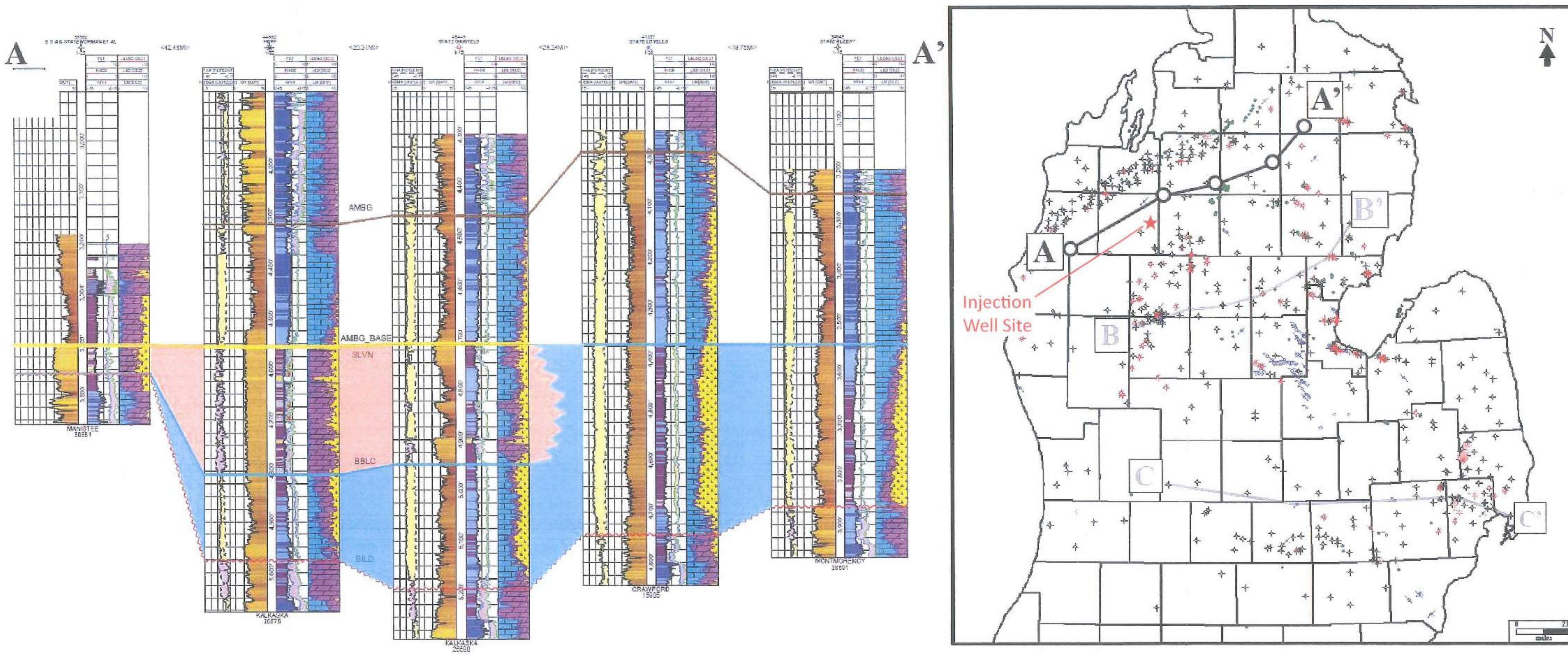

From: Pollard, 2013

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Figure F-22c
Regional A-A' Cross Section,
Sub Detroit River

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-22c.ai	By: JLM	Checked: CW

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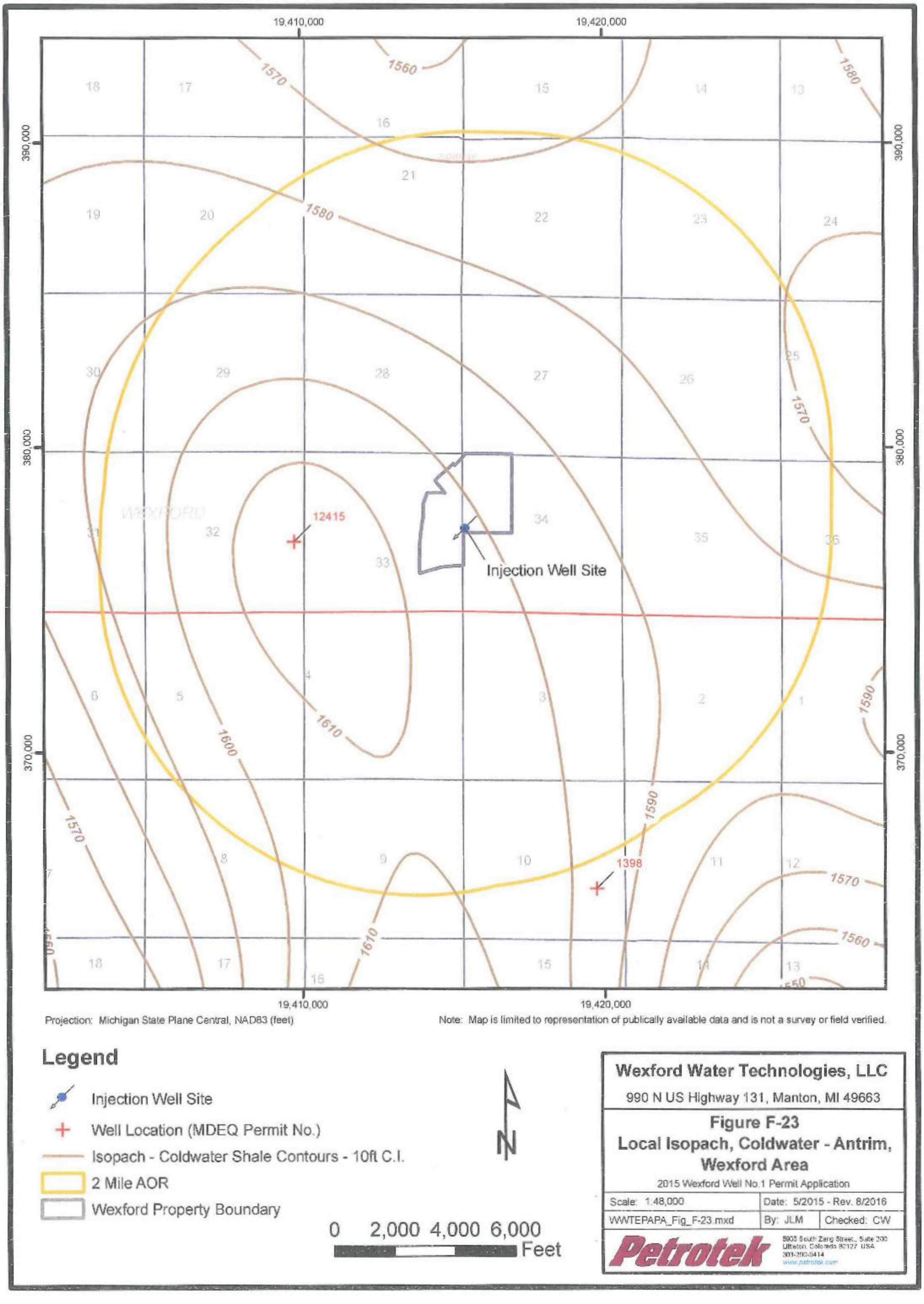
19,410,000
19,420,000
390,000
380,000
370,000
1560
1570
1580
1590
1600
1610
12415
1398
Injection Well Site
Projection: Michigan State Plane Central, NAD83 (feet)
Note: Map is limited to representation of publically available data and is not a survey or field verified.
Legend
Injection Well Site
Well Location (MDEQ Permit No.)
Isopach - Coldwater Shale Contours - 10ft C.I.
2 Mile AOR
Wexford Property Boundary
N
0 2,000 4,000 6,000
Feet
Wexford Water Technologies, LLC
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Figure F-23
Local Isopach, Coldwater - Antrim, Wexford Area
2015 Wexford Well No.1 Permit Application
Scale: 1:48,000
Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-23.mxd
By: JLM
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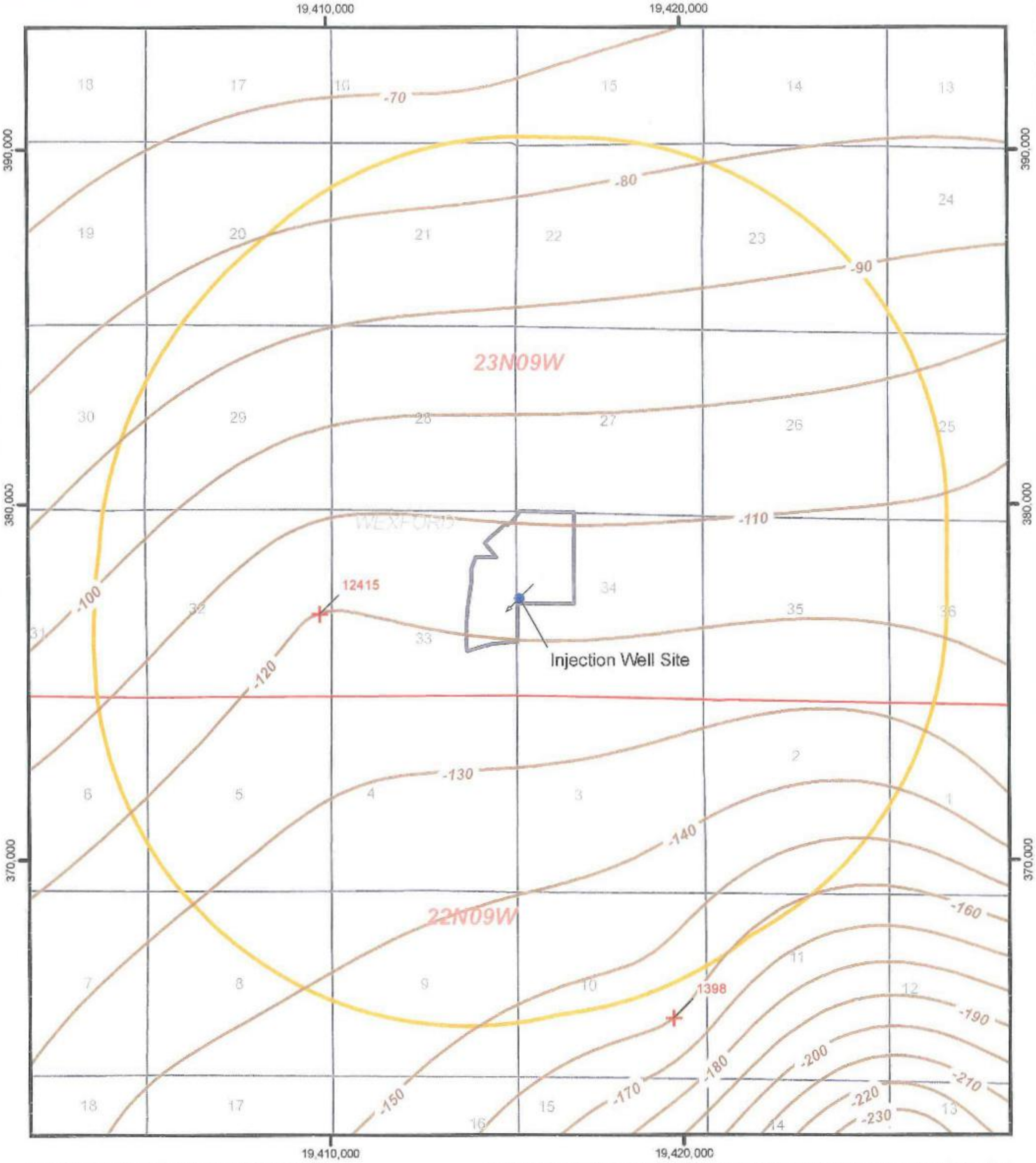

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to represenlation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Structure - Coldwater Shale Contours - 10ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

0 2,000 4,000 6,000 Feet

N

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Figure F-24
Local Structure Contour,
Top of Coldwater

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016
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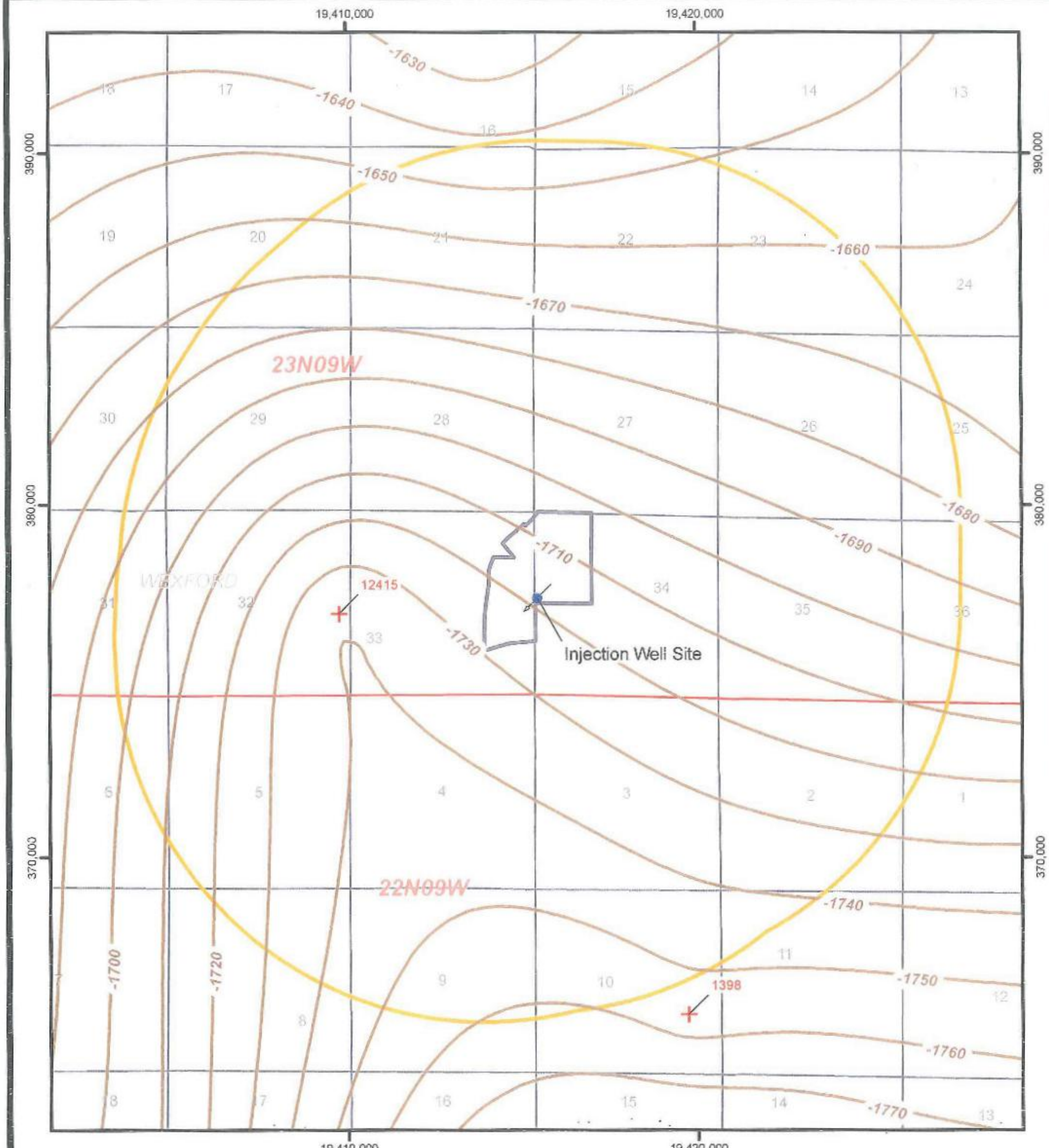

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Structure - Traverse Group Contours - 10ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

N

0 2,000 4,000 6,000 Feet

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Figure F-25a
Local Structure Contour, Traverse Formation

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-25a.mxd	By: JLM	Checked: CW

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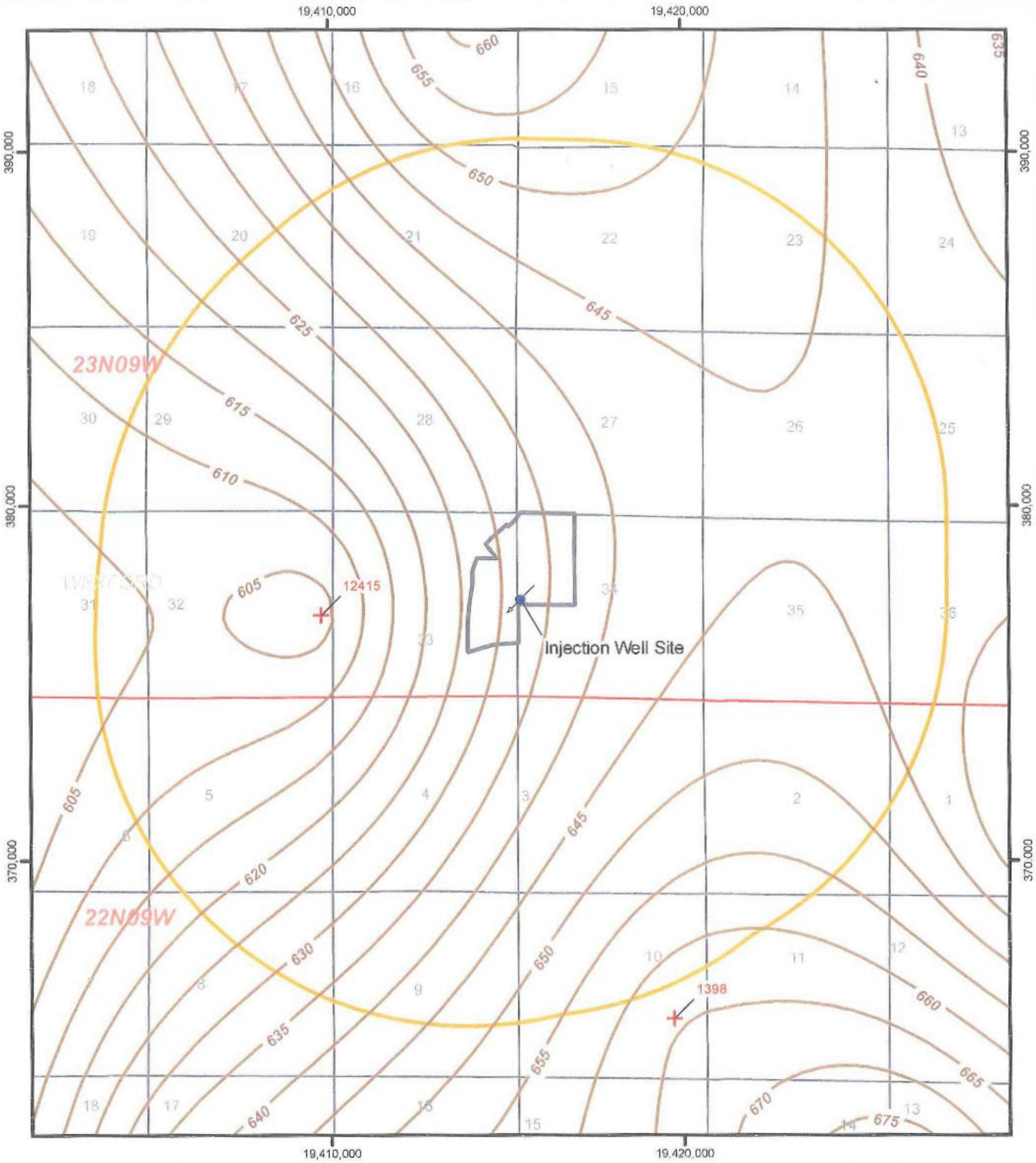

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Isopach - Traverse Group Contours - 5ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

0 2,000 4,000 6,000 Feet

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Figure F-25b
Local Isopach, Traverse Group, Wexford Area

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-25b.mxd	By: JLM	Checked: CW

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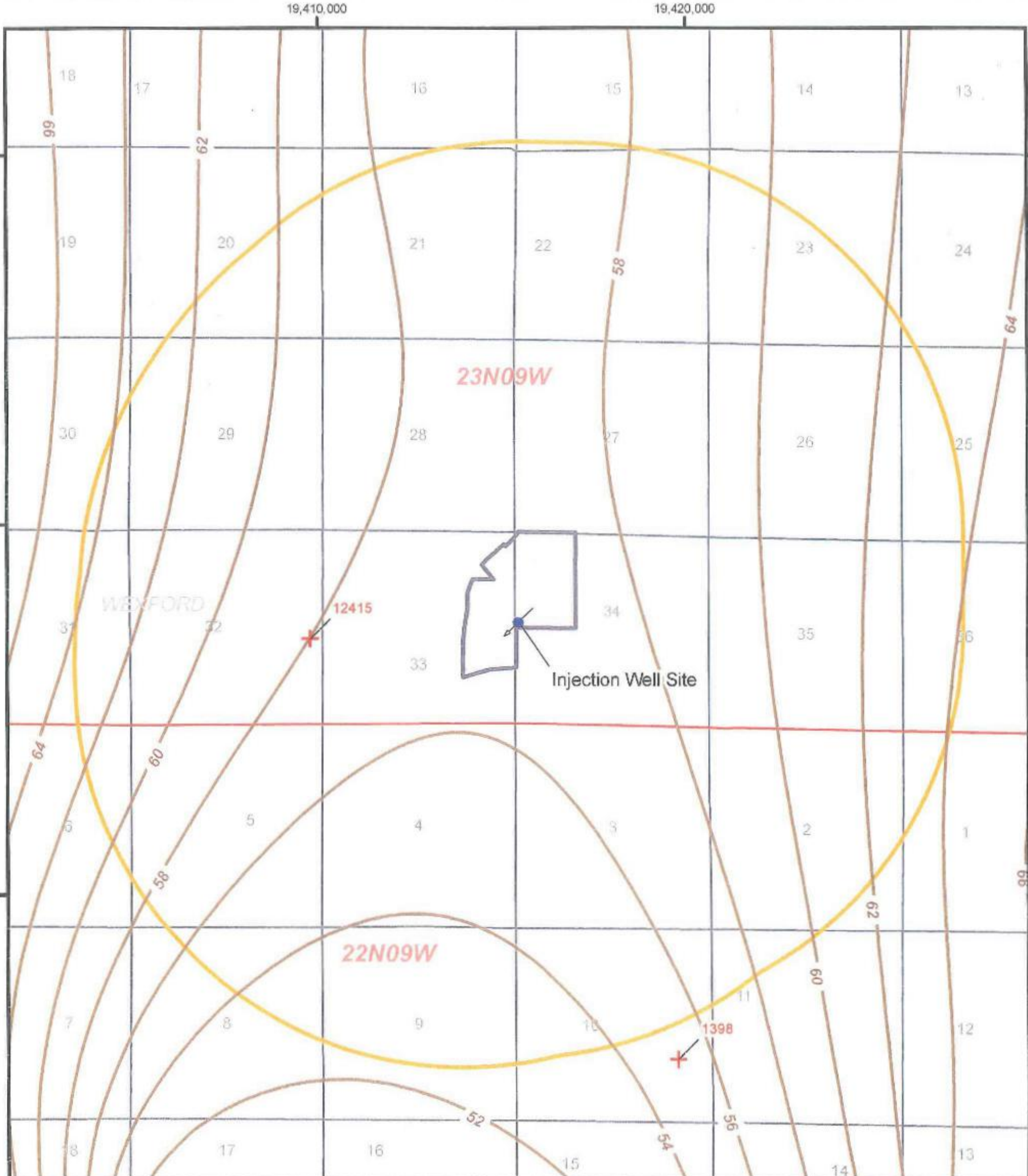

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Isopach - Bell Shale Contours - 2ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

0 2,000 4,000 6,000 Feet

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Figure F-26
Local Isopach, Bell Shale, Wexford Area

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-26.mxd	By: JLM / Checked: CW

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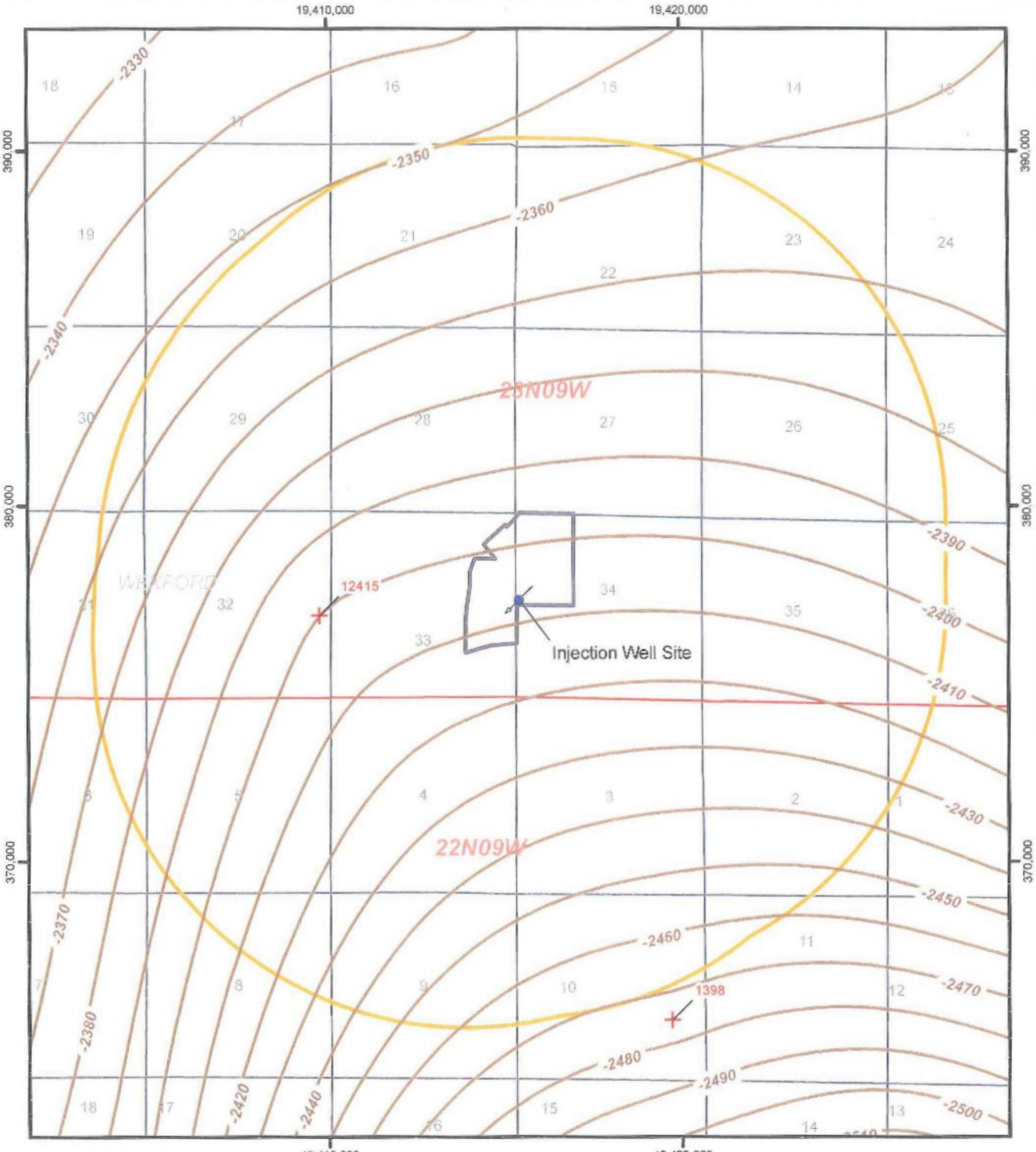

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Structure - Dundee Contours - 10ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

0 2,000 4,000 6,000 Feet

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Figure F-27a
Local Structure Contour, Dundee, Wexford Area

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016
WWTEPAPA_Fig_F-27a.mxd	By: JLM · Checked: CW

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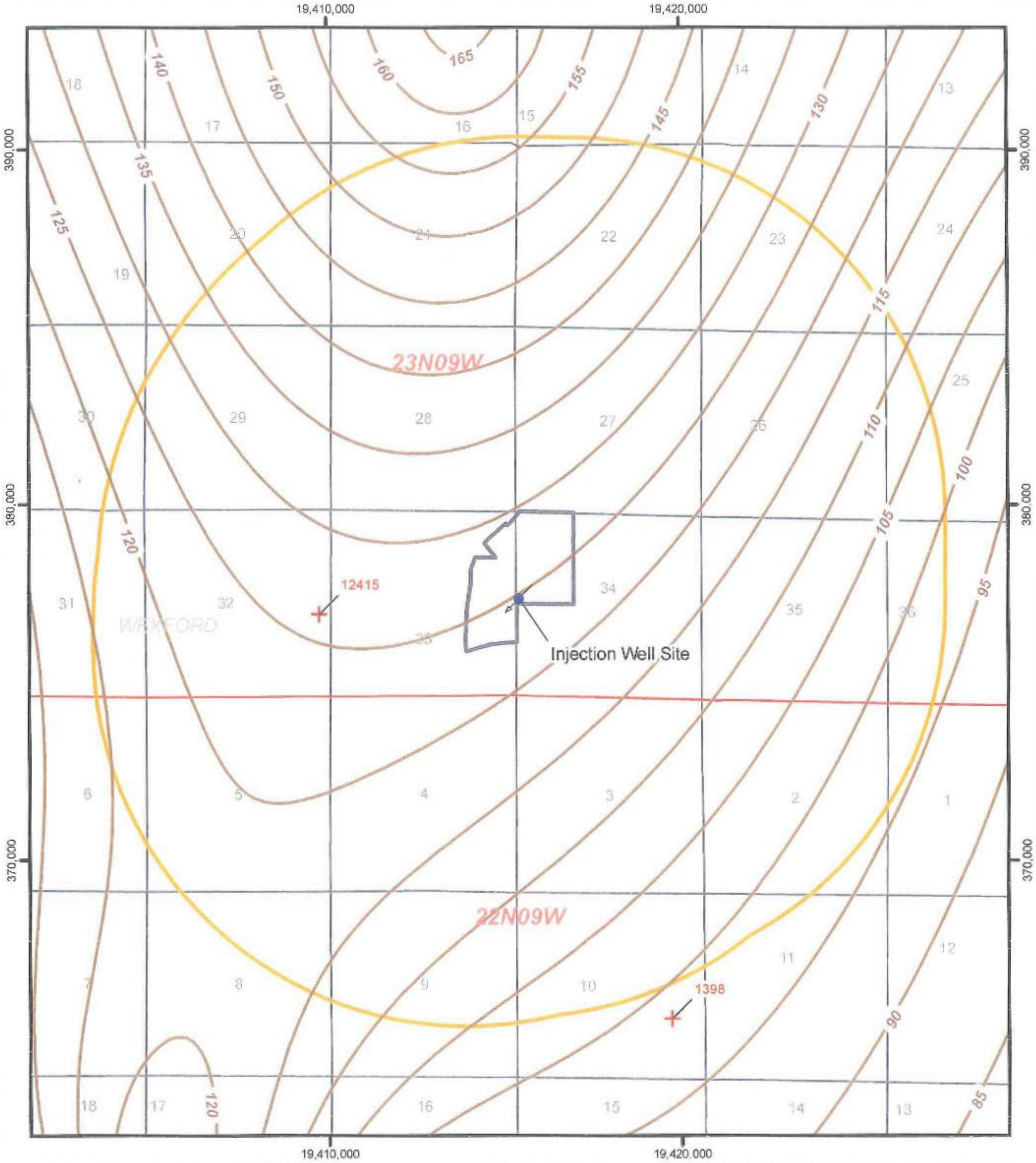

Projection: Michigan State Plane Central, NAD83 (feet)

Note: Map is limited to representation of publically available data and is not a survey or field verified.

Legend

- Injection Well Site
- Well Location (MDEQ Permit No.)
- Isopach - Dundee Contours - 5ft C.I.
- 2 Mile AOR
- Wexford Property Boundary

N

0 2,000 4,000 6,000 Feet

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Figure F-27b
Local Isopach, Rogers Member of the Dundee, Wexford Area

2015 Wexford Well No.1 Permit Application

Scale: 1:48,000	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-27b.mxd	By: JLM	Checked: CW

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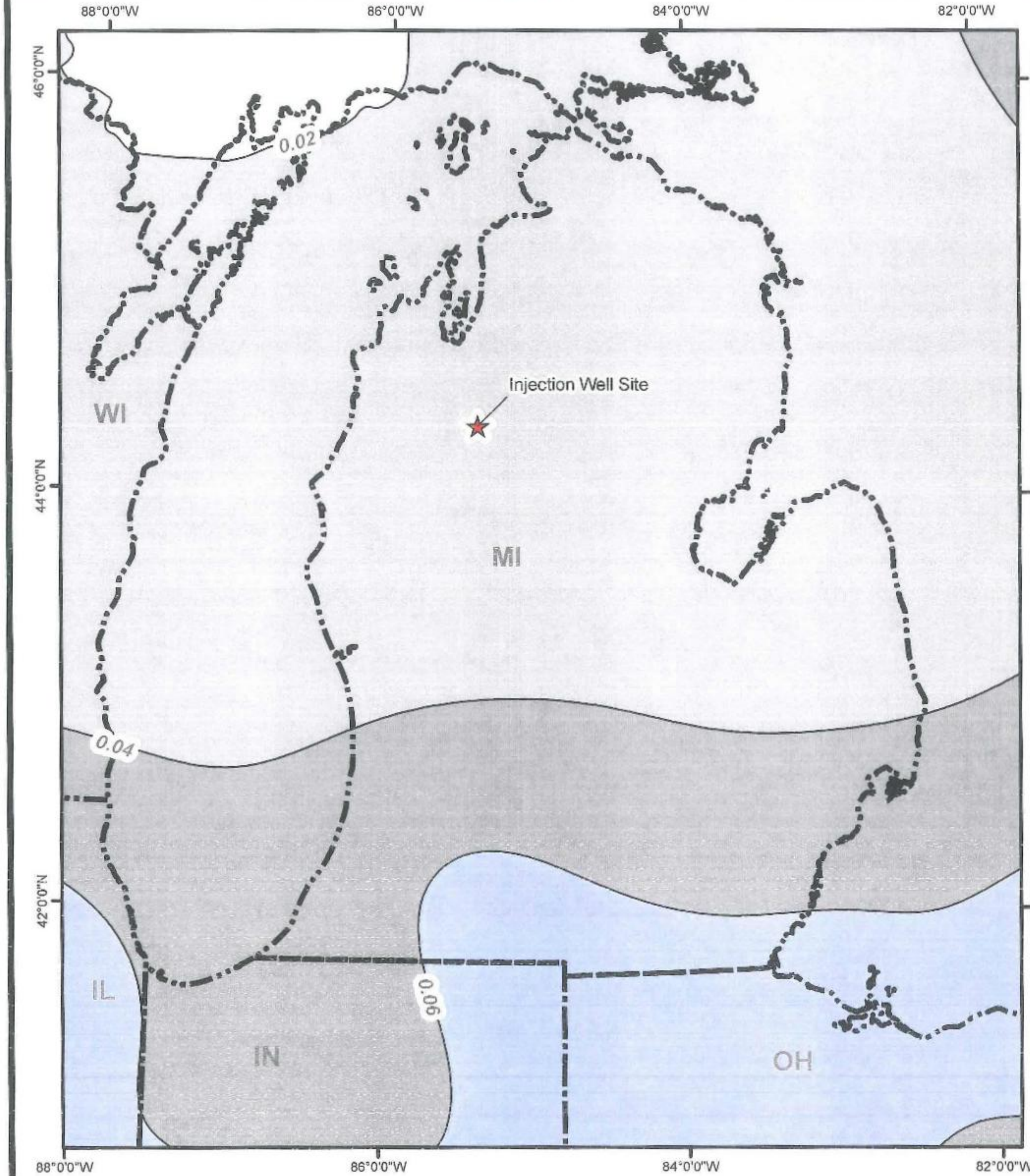

EXPLANATION
Peak acceleration, expressed as a fraction of standard gravity (g)

0.8 - 1.0	0.1 - 0.14
0.4 - 0.8	0.06 - 0.1
0.3 - 0.4	0.04 - 0.06
0.2 - 0.3	0.02 - 0.04
0.14 - 0.2	0 - 0.02

N

0 15 30 45 Miles

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Figure F-28
Seismic Peak Acceleration Map

2015 Wexford Well No.1 Permit Application

Scale: 1:3,000,000	Date: 5/2015 - Rev. 8/2016	
WWTEPAPA_Fig_F-28.mxd	By: JLM	Checked: CW

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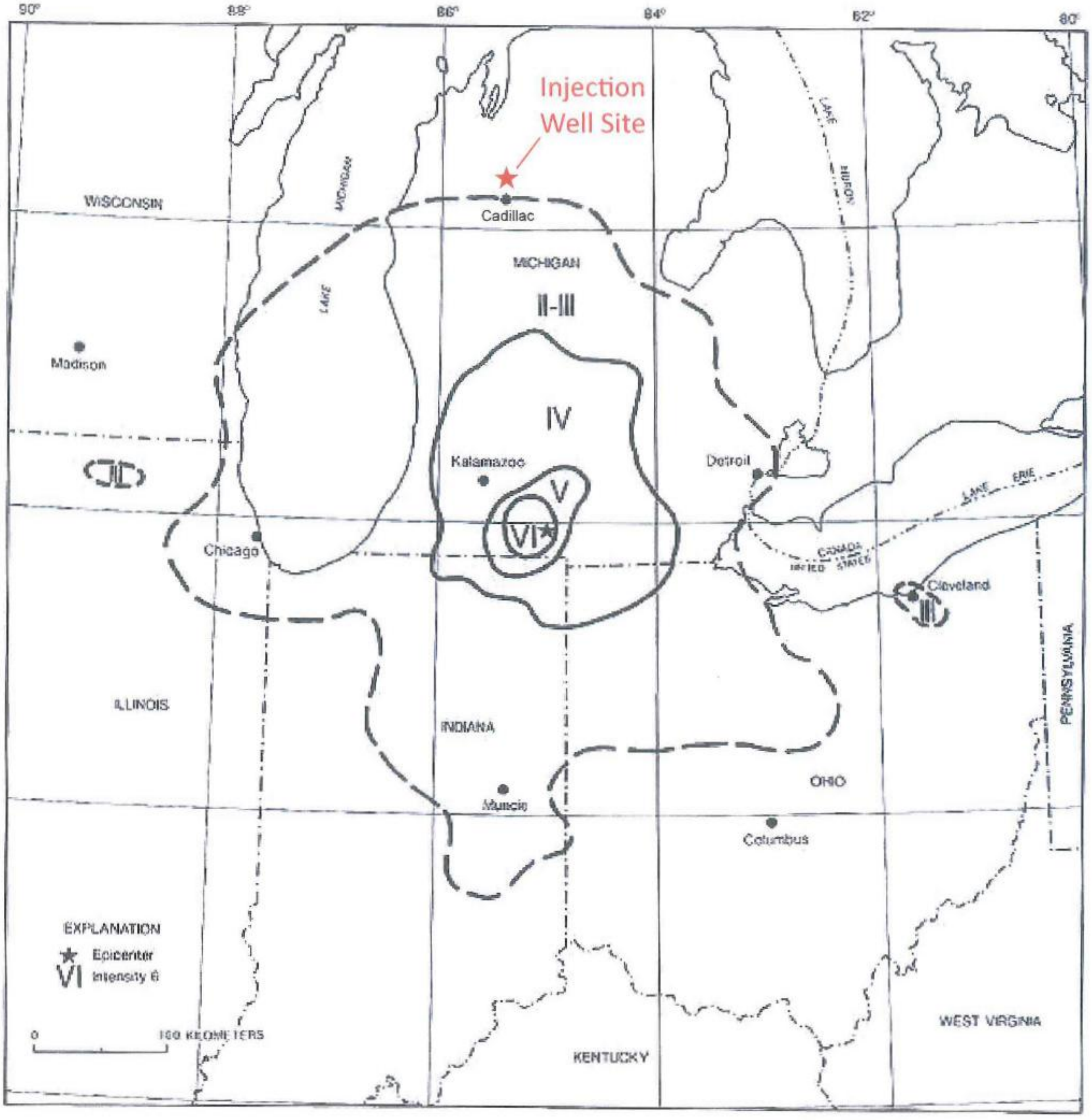

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Figure F-29
Location of Magnitude 4.5 Michigan Earthquake that occured August 9, 1947

2015 Wexford Well No.1 Permit Application

Scale: See Bar Scale	Date: 5/2015 - Rev. 8/2016	
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2.G. GEOLOGICAL DATA ON INJECTION AND CONFINING ZONES

For Class II Wells (Not Applicable to this Application)

2.H OPERATING DATA

Submit the following proposed operating data for each well (including all those to be covered by area permits): (1) average and maximum daily rate and volume of the fluids to be injected; (2) average and maximum injection pressure; (3) nature of annulus fluid; (4) for Class I wells, source and analysis of the chemical, physical, radiological and biological characteristics, including density and corrosiveness, of injection fluids. If the information is proprietary, maximum concentrations only may be submitted, but all records must be retained.

Response:

RATES, VOLUMES AND PRESSURES

The WWT well has been designed for operation under positive pressure to be supplied by using an injection pump. Although no site specific data are available, Region 5 USEPA Guidance #7 includes a default value of 0.8 psi/ft for the fracture gradient of the Dundee. If injection fluid is assumed to be comprised of a brine with a maximum specific gravity of 1.05 (plus a 0.02 safety margin) that fills the tubing from the surface to a maximum depth of 3,166 feet (estimated top of the Traverse Formation), a maximum wellhead injection pressure of 1,066 psi is calculated based on this Region 5 assigned gradient. No allowances for tubing friction are included in this calculation as a further safety margin. Note that the average specific gravity is actually expected to be in the 1.00 to 1.03 range. Without the 0.02 specific gravity safety margin, the maximum wellhead injection pressure is 1,093 psi.

The maximum pressure exerted by injectate of a 1.03 specific gravity at the top of the Traverse injection zone formation (estimated to be 3,166 feet BGL) is not likely to exceed 1,412 psi. If a safety margin of 0.02 is applied to the specific gravity the resulting hydrostatic pressure would be 1,439 psi and assuming the requested wellhead injection pressure of 1,066 yields psi, a total downhole pressure of 2,505 psi would exist. The downhole pressure is still below the calculated bottomhole Pff of 2,533 psi (3,166 ft x 0.8 psi/ft) with friction losses neglected (which offers even more of a safety margin).

Data regarding projected rates are based on recent historical landfill leachate collection system operating history. Table H-1 shows recent injection volume per month. As shown here, injection is expected to average 20,000,000 gallons in any given year. However, an injection volume of 2,500,000 gallons per month (30,000,000 gallons per year) has been requested.

Table H-1
Wexford County Landfill 2014 Monthly Leachate Generation Volume

2014 Month	MONTHLY VOLUME, gallons
January	1,212,261
February	914,685
March	1,063,300
April	1,160,109
May	1,969,989
June	1,927,346
July	1,793,570
August	1,212,367
September	1,745,312
October	1,935,906
November	1,834,807
December	2,406,359
TOTAL	19,176,011

The well is to be operated, and operating data reported, according to the following requirements:

Table H-2
WWT Well No. 1 Operating, Monitoring and Reporting Requirements

Characteristic	Value	Minimum Monitoring Frequency	Minimum Reporting Frequency
Cumulative Estimated Annual Volume	30 million gal/year	continuous	monthly
Injection Rate (maximum)	84 gpm max.	continuous	monthly
Injection Rate (average)	57 gpm ave.	continuous	monthly
Injection Pressure (maximum)	1,066 psig max.	continuous	monthly
Injection Pressure (average)	500 psig ave.	continuous	monthly
Annulus/Tubing Pressure Differential	100 psig min.	continuous	monthly
Sight Glass Level	tank level	daily when operated	monthly
Annulus Fluid Add/Subtract	volume	per event	monthly
Chemical Composition of Injected Fluids[1]	-	Quarterly	within 30 days of sampling
Physical Characteristics of Injected Fluids[1]	-	variable	within 30 days of sampling

1 As specified in the Waste Analysis Plan

INJECTATE CHARACTERISTICS

Non-hazardous fluid generated on-site from the primary and leachate collection system will be disposed in WWT Well No. 1. If needed, associated local groundwater derived from the landfill site and fluids derived from or necessary for the maintenance and repair of the well may also be injected. Fluids will be transferred by pipe from the capture system units to storage tanks where the leachate will be comingled prior to injection. The primary collection system constitutes over 99% of the total waste volume. Under the Wexford County Landfill Operating License, water within Cells A, B, C, D & E, F, G and J is monitored for total leachate volume on a monthly basis and water quality on a quarterly basis as described in the Hydrogeologic Monitoring Plan (Golder Associates, 2012). Waste water is collected at the primary leachate collection sumps in each cell, then is transferred by pipeline or truck to the leachate holding tank. In addition to water from the primary leachate collection system, water will also be collected from secondary leachate collection points if necessary. Secondary leachate will be transferred on site through the leachate forcemain to the leachate collection tank. A single sample is collected by bailer from the leachate collection tank on a quarterly basis, and analyzed for the parameters specified in the Hydrogeologic Monitoring Plan required by the Landfill Operating License (Attachment H at the end of Section 2.H). Attachment H also presents the total monthly volume and quarterly monitoring results for 2013 and 2014.

Leachate is currently being disposed of by deep well injection elsewhere as permitted by the EPA and MDEQ, and specific analysis is performed on that injectate. Leachate analysis performed prior to offsite disposal on January 22, 2015 is summarized in Table H-3. This analysis shows that leachate contains almost no detected organic compounds, with a TDS of 6,800 ppm.

Table H-3
Leachate Analysis Wexford County Landfill, January 22, 2015

Analysis	Concentration	Limit of detection	Units
1,4-Dichlorobenzene	ND	0.1	mg/L (PPM)
2,4,5-Trichloroph Enol	ND	0.1	mg/L (PPM)
2,4,6-Trichlorophenol	ND	0.1	mg/L (PPM)
2,4-Dinitrotoluene	ND	0.05	mg/L (PPM)
Hexachlorobenzene	ND	0.05	mg/L (PPM)
Hexachlorobutadiene	ND	0.1	mg/L (PPM)
Hexachloroethane	ND	0.1	mg/L (PPM)
P,M-CRESOL (3&4-METHYLPHENOL)	ND	0.1	mg/L (PPM)
Nitrobenzene	ND	0.1	mg/L (PPM)
O-Cresol (2-Methylphenol)	ND	0.1	mg/L (PPM)
Pentachlorophenol	ND	0.2	mg/L (PPM)
Pyridine	ND	0.1	mg/L (PPM)
Alkalinity Sm2320-Bicarb	2230	10	mg/L (PPM)
Alkalinity Sm2320-Total	2230	10	mg/L (PPM)

Table H-3
Leachate Analysis Wexford County Landfill, January 22, 2015

Analysis	Concentration	Limit of detection	Units
Barium EPA 200.8	0.93	0.5	mg/L (PPM)
Calcium EPA 200.8	162	100	mg/L (PPM)
Chloride EPA 325.2	1500	30	mgfL (PPM)
Conductivity Sm2510-B	9800	200	uS/cm
Cyanide-Reactive	ND	8.6	PPM
Flashpoint EPA 1010	> 200		DEGREES F
Iron EPA 200.8	12.8	1	mg/L (PPM)
Magnesium EPA 200.8	195	100	mg/L (PPM)
Ph EPA 9040	7.4	+/- 0.1	s.u.
Potassium EPA 200.8	676	100	mg/L (PPM)
Residue, Filterable(TDS)/SM2540c	6800	200	mg/L (PPM)
Resistivity	1.02		ohm-m
Sodium - EPA 200.8	861	100	mg/L (PPM)
Specific Gravity	0.9731		
Sulfate EPA 375.4	40	10	mg/L (PPM)
Sulfide EPA 376.2	0.48	0.4	mg/L (PPM)
Sulfide-Reactive	ND	6.6	PPM
Arsenic EPA 6020-TCLP	0.025	0.02	mg/L(PPM)
Barium EPA 6020-TCLP	0.93	0.5	mg/L (PPM)
Cadmium EPA 6020-TCLP	ND	0.01	mg/L (PPM)
Chromium EPA 6020-TCLP	ND	0.1	mg/L (PPM)
Lead EPA 6020-TCLP	ND	0.02	mg/L (PPM)
Mercury EPA 7470-TCLP	ND	0.005	mg/L (PPM)
Selenium EPA 6020-TCLP	0.059	0.05	mg/L (PPM)
Silver EPA 6020-TCLP	ND	0.002	mg/L (PPM)
Benzene	276	50	ug/L (PPB)
Carbon Tetrachloride	ND	50	ug/L (PPB)
Chlorobenzene	ND	50	ug/L (PPB)
Chloroform	ND	50	ug/L (PPB)
1,2-Dichloroethane	ND	50	ug/L (PPB)
1,1-Dichloroethene	ND	50	ug/L (PPB)
Methyl Ethyl Ketone	ND	250	ug/L (PPB)
Tetrachloroethene	ND	50	ug/L (PPB)
Trichloroethane	ND	50	ug/L (PPB)
Vinyl Chloride	ND	50	ug/L (PPB)
1,2-Dichlorobenzene	ND	50	ug/L (PPB)

Impact of Injection

There are no deep disposal wells of any type in the immediate vicinity of the Wexford County Landfill. However, two wells in the region were associated with well injection or extraction, and are now abandoned. The State Liberty 1-18 well (Permit 35099) occurs approximately 10 miles north of the Wexford County Landfill. This well was drilled in 1982 as an oil and gas well to the Traverse. The well was not productive, but the owners then obtained a special use permit to operate the well for brine disposal. The well was plugged and abandoned in 1984, reportedly due to business reasons. The Solon-Webb No. 1 well (Well Permit 25348) is located approximately four miles south of the Wexford County Landfill, and was operated as a Traverse brine extraction well from about 1964 to approximately 1988. The brine was used by local municipalities for road deicing, and when this use ceased, the well was abandoned and formally plugged under the state Orphan Well Program in 2007. Brine production rates are not available. Traverse and/or Dundee permeability and porosity is anticipated, and will be tested to verify capacity upon well installation. Until data are obtained during installation of the well, conservative estimates of formation properties have been assigned based on regional data and projected operational parameters, to generate an estimate of the fluid front for the WWT Well No. 1.

Standard equations for the volume of a porous cylinder can be used with the following parameters to generate an estimate for a simplistic piston-like displacement fluid front radius: Based on parameters determined at Well Permit No 39695, the following was assumed:

- 348-foot net combined Traverse & Dundee thickness with 10% porosity
- 600,000,000 gallons of injectate estimated based on twenty years of continuous injection at a rate of 30,000,000 gallons per year (57 gpm).

As an estimate for illustrative purposes, this calculation yields a 100 percent injected fluid front radial distance of approximately 857 feet from the well. Although dispersion will play a role in spreading this plume over a slightly larger area, even a relatively large dispersivity combined with a low concentration of interest would likely yield a plume that reaches a radial distance of less than 1/4 mile from the well. This is significantly smaller than the distance to the nearest offset well (approximately 5,650') and much smaller than the 2-mile area of review radius for which well locations were identified and evaluated. Additional evaluation of dispersion, diffusion and/or displacement of injected fluids and behavior of transient pressure gradients in the injection zone during and following injection will be conducted upon site-specific information becoming available from testing the well.

Compatibility problems encountered due to injection of non-hazardous leachate would likely be due to injection of particulate matter that could cause decreased flow capacity. Due to the composition of the waste stream and landfill origin, periodic biocide treatments will be instituted as needed to prevent the establishment of bacterial plugging issues. Also, it is possible that the concentration of iron within injectate could lead to precipitation issues within tubing, pipe, or the formation, so implementation of a system to prevent plugging or treat iron may be required. Such solids, compatibility or bacterial problems, if they do occur, would not be a containment issue, but would be an operations issue. If plugging occurred and was not remedied, the operator could reduce injection rates so that maximum pressure limits are not exceeded. To sustain rates if such a situation develops, periodic stimulations may be required, but would be accomplished within regulatory requirements. At this time, only relatively low suspended solids wastes from the Wexford County Landfill leachate facility will be injected in the well.

Michigan Department of Environmental Quality
Office of Waste Management and Radiological Protection

SOLID WASTE DISPOSAL AREA OPERATING LICENSE

This license is issued under the provisions of Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, MCL 324.11501 et seq., and authorizes the operation of this solid waste disposal area (Facility) in the state of Michigan. This license does not obviate the need to obtain other authorizations as may be required by state law.

FACILITY NAME: Wexford County Landfill, LLC

LICENSEE/OPERATOR: Wexford County Landfill, LLC

FACILITY OWNER: Wexford County Landfill, LLC

PROPERTY OWNER: Wexford County Landfill, LLC

FACILITY TYPE(S): Municipal Solid Waste Landfill

FACILITY ID NUMBER: 470336

COUNTY: Wexford

LICENSE NUMBER: 9405

ISSUE DATE: August 29, 2014

EXPIRATION DATE: August 29, 2019

FACILITY DESCRIPTION: The Wexford County Landfill, LLC, a municipal solid waste landfill, consists of 196.4 acres located at 990 North US Highway 131, Manton, Michigan 49663, in the W 1/2 of the NW 1/4 of Section 34 and the E 1/2 of Section 33, T23N, R9W, Cedar Creek Township, Wexford County, Michigan, as identified in Attachment A and fully described in this license.

AREA AUTHORIZED FOR DISPOSAL OF SOLID WASTE: Cell B, 4.8 acres; Cell C, 4.0 acres; Cell D & E, 8.2 acres; Cell F, 6.3 acres; Cell G-Phase 1, 5.3 acres; Cell G-Phase II, 4.6 acres; and Cell J1, 3.1 acres; for a total of 36.3 acres. Unconstructed Cell J2 (1.1 acres) and Cell G3, (10 acres), for a total of 11.1 acres with financial assurance, is authorized for solid waste disposal upon being constructed and having the engineering certification approved by the Michigan Department of Environmental Quality (MDEQ).

RESPONSIBLE PARTY: Mr. Edward G. Ascione, Member
Wexford County Landfill, LLC
3947 N. US 131
P.O. Box 1030
Kalkaska, Michigan 49646
Phone: 231-258-9030

RENEWAL OPERATING LICENSE: This License Number 9405 supersedes and replaces Solid Waste Disposal Area Operating License Number 9366 issued to Wexford County Landfill, LLC, on December 12, 2013.

This license is subject to revocation by the Director of the Michigan Department of Environmental Quality, if the Director finds that this Facility is not being constructed or operated in accordance with the approved plans, the conditions of a permit or license, Part 115, or the rules promulgated under Part 115. Failure to comply with the terms and provisions of this license may result in legal action leading to civil and/or criminal penalties pursuant to Part 115. This license shall be available through the licensee during its term and remains the property of the Director.

THIS LICENSE IS NOT TRANSFERABLE.

Steven R. Sliver, Chief, Solid Waste Section
Office of Waste Management and Radiological Protection

The licensee shall comply with all terms of this license and the provisions of Part 115 and the administrative rules implementing Part 115 (Part 115 Rules). This license includes the license application and any attachments to this license.

1. The licensee shall operate the Facility in a manner that will prevent violations of any state or federal law.

2. The following portions of the Facility are authorized to receive solid waste by this license:

   ACTIVE PORTIONS NOT AT FINAL GRADE: The area(s) identified as Cell B, 4.8 acres; Cell C, 4.0 acres; Cell D & E, 8.2 acres; Cell F, 6.3 acres; Cell G - Phase I, 5.3 acres; Cell G - Phase II, 4.6 acres; and Cell J1, 3.1 acres were authorized to receive waste by the previous license. This area's total acreage is 36.3 acres.

3. The following portions of the Facility **WILL BE** authorized to receive solid waste by this license following approval by the MDEQ of construction certification:

   UNCONSTRUCTED AREA(S) WITH FINANCIAL ASSURANCE: The area(s) identified as Cell J2 (1.1 acres) and Cell G3 (10 acres), totaling 11.1 acres, are included in the calculation of financial assurance as required by Section 11523 of Part 115. This portion(s) of the Facility shall be authorized to receive waste, as part of this license, when acceptable certification is submitted to the MDEQ, as required by Section 11516(5) of Part 115, and determined by the MDEQ to be consistent with Part 115 and the Part 115 Rules. The certification shall verify that construction of this area(s) was in accordance with the Construction Permit(s) listed in Item 8 of this license, Part 115, and the Part 115 Rules.

4. The following portions of the Facility are **NOT** authorized to receive solid waste by this license:

   UNCONSTRUCTED AREA(S) WITHOUT FINANCIAL ASSURANCE: The area(s) identified as the East Unit: Cell H, 11.1 acres; and Cell 1, 10.7 acres; and the West Unit: Cell 1, 7.6 acres; Cell 2, 8.8 acres; Cell 3, 12.6 acres; Cell 4, 7.4 acres; Cell 5, 7.4 acres; Cell 6, 7.5 acres; Cell 7, 5.3 acres; Cell 8, 4.5 acres; and Cell 9, 7.4 acres are not constructed and are not included in the calculation of financial assurance as required by Section 11523 of Part 115. This area's total acreage is 90.3 acres.

5. The attached map (Attachment A) shows the Facility, the area permitted for construction, monitoring points, leachate storage units, site roads, other disposal areas, and related appurtenances.

6. Issuance of this license is conditioned on the accuracy of the information submitted by the Applicant in the Application for License to Operate a Solid Waste Disposal Area (Application) received by the MDEQ on June 3, 2014, and any subsequent amendments. Any material or intentional inaccuracies found in that information is grounds for the revocation or modification of this license and may be grounds for enforcement action. The licensee shall inform the MDEQ's Office of Waste Management and Radiological Protection (OWMRP), Cadillac District Supervisor, of any inaccuracies in the information in the Application upon discovery.

7. This license is issued based on the MDEQ's review of the Application, submitted by Wexford County Landfill, LLC, for the Wexford County Landfill, LLC, dated May 28, 2014, with revisions dated June 26, 2014, and August 15, 2014. The Application consists of the following:

   a. Application Form EQP 5507.

   b. Application fee in the amount of $3,750.00.

   c. Certification of construction by N/A.

   d. Waste Characterization: N/A.

e. Restrictive Covenant:

The Wexford County Landfill, LLC, restrictive covenant on 196.98 acres is on file at the Wexford County Register of Deeds recorded on June 20, 2011, as Liber 640 pages 659-664. A copy is on file with the MDEQ.

f. Perpetual Care Fund Agreement, established as an escrow account, signed by Mr. Michael A. Ascione, Member, Wexford County Landfill, LLC, on August 23, 2011, was executed by the MDEQ on September 30, 2011.

g. Financial Assurance.

i. Financial Assurance Required:

The amount of financial assurance required for this Facility was calculated based on the calculation worksheet form EQP 5507A entitled, "Form A, Financial Assurance Required," and is $8,385,937.20.

The Facility has provided financial assurance totaling $8,441,567.82, based on the requirements of Section 11523 of Part 115, consisting of a combination of the Perpetual Care Fund established under Section 11525 of Part 115, bonds, and the financial capability of the Applicant as evidenced by a financial test. The financial assurance mechanisms used by the Facility are summarized below in Items ii, and iii, respectively.

ii. Financial Assurance Provided Via a Perpetual Care Fund:

(1) The amount of the required financial assurance can be reduced pursuant to Section 11524 of Part 115, if the amount of money in the Perpetual Care Fund plus the amount of the reduced financial assurance equals the amount of financial assurance required in Section 11523 of Part 115 and is approved by the MDEQ.

(2) The Perpetual Care Fund Agreement statement showed a balance of $1,914,736.12 in the Facility's Perpetual Care Fund as of September 30, 2013. Of this amount, the MDEQ has granted the request to use $1,914,736.12 toward the total amount of financial assurance required.

iii. Financial Assurance Provided Via Bond:

The following financial assurance has been received from the Applicant to meet the amount of financial assurance required:

Surety Bond	$6,526,831.70
Total Amount Received:	$6,526,831.70

iv. Financial Assurance Updates Required:

For Type II landfills, the financial assurance cost estimates of closure and postclosure activities must be updated annually and the corresponding requisite amount of financial assurance must be adjusted annually for the costs of inflation. The corresponding financial assurance, as adjusted for inflation and other factors, is due on August 29, 2015, and each year thereafter.

v. Other Required Financial Assurance: The Wexford County Department of Public Works (DPW) maintains a financial assurance mechanism, totaling $987,000.00, for the Wexford County Landfill's Remedial Action Plan (RAP), approved by the MDEQ on October 9, 2007. See Item 20. Special Conditions (b.) of this license.

8. The following documents approved with Construction Permit Number(s) 4100 and 4127 issued to the Wexford County DPW and Wexford County Landfill, LLC, on November 17, 2008, and August 20, 2012, are incorporated in this license by reference:

   a. 2008 Expansion Permit, Wexford County Landfill, Environmental Assessment Report, prepared by CTI and Associates, Inc. (CTI), dated May 2008.
   b. 2008 Expansion Permit, Wexford County Landfill, Engineering Report, prepared by CTI and dated May 2008, with revisions October 2008.
   c. 2008 Expansion Permit, Wexford County Landfill, Hydrogeological Report, prepared by CTI and dated May 2008.
   d. 2008 Expansion Permit, Wexford County Landfill, Hydrogeological Monitoring Plan (HMP), prepared by CTI and dated May 2008. (See revised Hydrogeological Monitoring Plan (HMP), Item 9b of this license.)
   e. 2008 Expansion Permit, Wexford County Landfill, Engineering Plan Set, Wexford County, Michigan, prepared by CTI and dated October 2008.
   f. "Remedial Action Plan - Final Wexford County Landfill," prepared by CTI and dated August 6, 2007. It was approved by the MDEQ on August 9, 2007.
   g. Limited Agreement for a Residential Remedial Action entered between the MDEQ and Wexford County, effective October 2007.
   h. Wexford County Landfill, LLC, Construction Permit Application, Volumes 1 and 2, both dated April 19, 2012, and revised June 11, 2012, and July 18, 2012; and Engineering Plans entitled Construction Permit Application, 2012 Expansion Permit, Wexford County Landfill, Wexford County, dated April 2012 and revised July 17, 2012.

9. The following additional documents, approved since the issuance of the construction permits referenced in Item 8, are incorporated in this license by reference:

   a. Wexford County Landfill, LLC, Solidification Plan, dated December 29, 2011, and approved by the MDEQ on January 11, 2012.
   b. Wexford County Landfill, LLC, HMP dated April 2012, with revisions July 2012.
   c. Leachate Recirculation Plan, dated July 2014.
   d. Odor Management Plan, dated July 2014.

10. Consent Order/Judgment Number: N/A.

11. The licensee shall repair any portion of the certified liner or leachate collection system that is found to be deficient or damaged during the term of this license unless determined otherwise by the MDEQ.

12. The licensee shall have repairs to any portion of the certified liner or leachate collection system recertified by a registered professional engineer in accordance with R 299.4921 of the Part 115 Rules and approved by the MDEQ before receiving waste in that portion of the certified liner or leachate collection system. The licensee shall submit the recertification to the MDEQ's OWMRP, Cadillac District Office Supervisor, for review and approval.

13. The licensee shall conduct hydrogeological monitoring in accordance with the approved hydrogeological monitoring plan, dated April 2012, with revisions July 2012. The sampling analytical results shall be submitted to the MDEQ's OWMRP, Cadillac District Office.

14. Modifications to the approved hydrogeological monitoring plan referenced in Item 13 may be approved, in writing, by the OWMRP, Cadillac District Supervisor. Proposed revisions must be submitted in a format specified by the MDEQ.

15. Leachate may be recirculated if a leachate recirculation plan has been approved, in writing, by the OWMRP, Cadillac District Supervisor.

16. Modifications to approved engineering plans that constitute an upgrading, as defined in R 299.4106a(l) of the Part 115 Rules, may be approved, in writing, by the OWMRP, Cadillac District Supervisor.

17. Requests for alternate daily cover may be approved, in writing, by the OWMRP, Cadillac District Supervisor.

18. Leakage Control Criteria:

The active portions of the unit(s) authorized to receive waste by this license is an unmonitorable unit(s) designed with a double-liner systems that is in compliance with the provisions of R 299.4422(3) of the Part 115 Rules and that is capable of detecting and collecting leakage through the primary composite liner. The action flow rate for each unit containing a leak detection system is 5 gallons/acre/day. The response flow rate for each unit containing a leak detection system is 25 gallons/acre/day.

19. **VARIANCES**: None.

20. **SPECIAL CONDITIONS**:

a. The licensee shall place a compacted layer of not less than six inches of earthen material, unless an exemption is granted, of suitable cover material on all exposed solid waste by the end of each working day, as required by R 299.4429(1) of the Part 115 Rules. Suitable cover shall be either uncontaminated soil or an alternate cover approved by the OWMRP, listed in Item i, below. Alternate cover shall be restricted as indicated in Item ii and applied as per the approved operational plan submitted by the licensee.

i. Approved alternate cover shall be any of the following:

(1)

Product/Waste Material	Source	Monthly Volume
Foundry Sand	Cadillac Castings, Inc.	Unlimited
Ash	Various	250 Tons
Auto Fluff	Various	1,650 Tons
Contaminated Soils	Various	500 Tons
Solidified Drilling Muds	Various	300 Tons
Solidified Soils	Various	450 Tons
Wood Chips	Various	200 Tons
Screened Compost Rejects	Various	200 Tons
Catch Basin Solids	Various	200 Tons
Oil & Gas Solids	Various	300 Tons

(2) Other materials approved in accordance with the provisions of the Alternate Daily Cover Materials Plan approved with Construction Permit Number 4127, issued August 20, 2012

iii. The above materials are approved for daily cover when used in the following manner:

(1) The licensee shall use the material as daily cover only. The material cannot be used for road building or fill in other areas of the Facility's operation.

(2) The licensee shall maintain copies of the testing performed on Class B and Class C materials in the facility operating record.

(3) The licensee shall only stockpile material in a secure manner within the active cell.

(4) This approval does not preclude the licensee from disposing of the material as waste in the active fill area instead of using the material as daily cover.

(5) This approval shall immediately become void upon documentation by the MDEQ that the alternative cover is not being used in accordance with listed conditions, that the alternative cover is not providing the necessary protection, that the material no longer meets the alternative daily cover guidelines, or that the process producing the waste material has changed.

(6) If the material does not meet the guidelines from Attachment 2 of Policy and Procedure OWMRP-115-10, for nonvolatiles, the licensee shall ensure that fugitive dust emissions from this material do not occur. Acceptable methods to ensure fugitive emissions do not occur are:

(a) Implement a schedule to wet down material; or

(b) Cover the material with a tarp; or

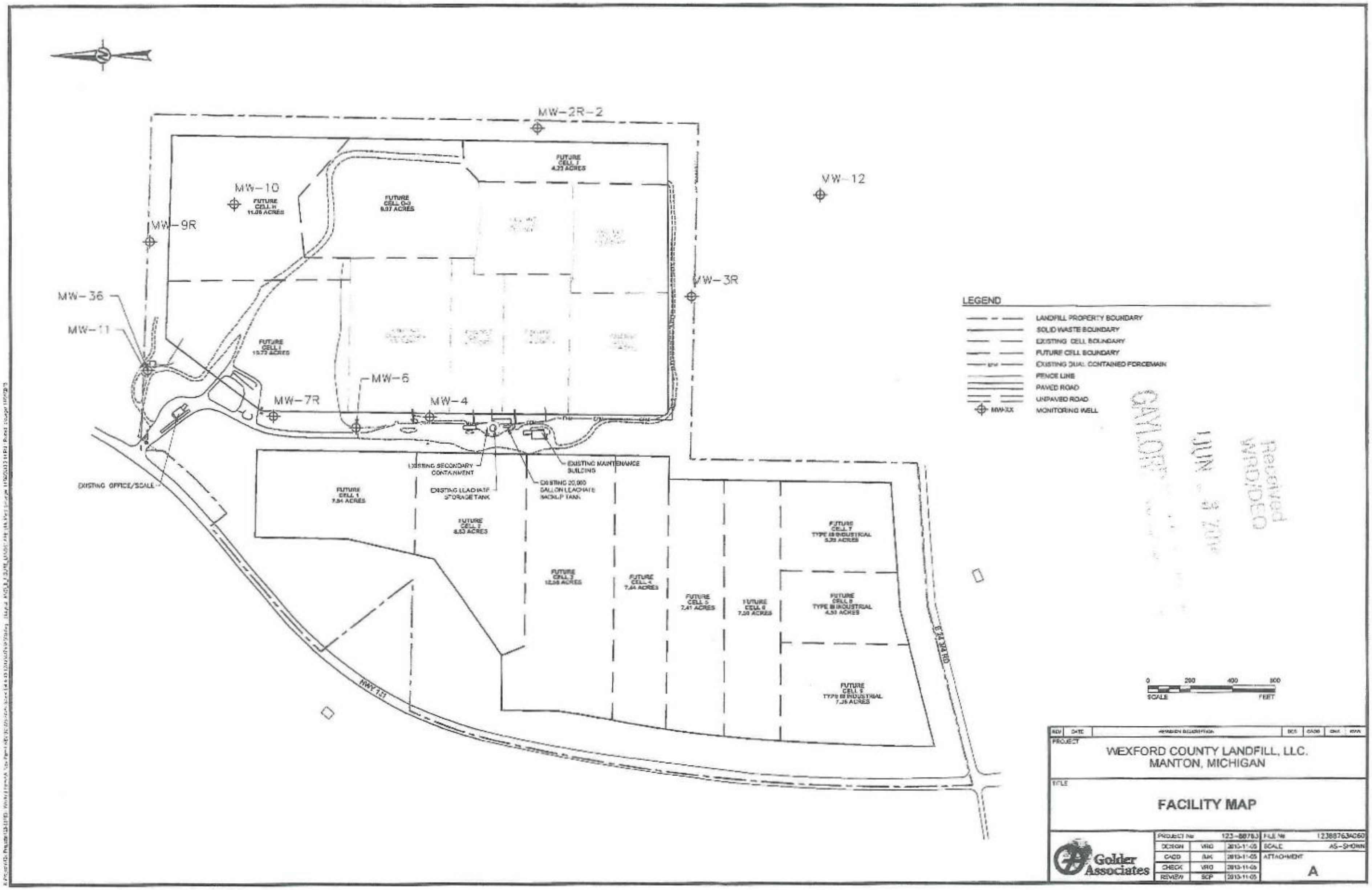
(c) Apply an approved foam or other appropriate commercial dust control product.

(7) This approval to use alternative cover shall expire upon expiration of this operating license.

b. On October 9, 2007, the MDEQ approved a "Limited Residential Remedial Action Plan" (RAP) for the Wexford County Landfill. On October 5, 2007, the MDEQ executed an "AGREEMENT FOR A LIMITED RESIDENTIAL REMEDIAL ACTION" to specify the agreed upon conditions for approval of the RAP, MDEQ Reference No. RAP LANDUSE WHMD-2007-A (Agreement). The Agreement specifies that the Wexford County DPW retain responsibilities under the Agreement to implement the RAP, regardless of transfer of ownership. R 299.4445(1)(b) of the Part 115 Rules requires, among other things, that the owner and operator of a solid waste disposal area (Wexford County Landfill, LLC,) shall implement the approved RAP. Wexford County Landfill, LLC, and the DPW have entered a contractual arrangement to ensure implementation of the RAP and financial assurance for such. This arrangement does not limit the MDEQ's ability to take any appropriate action under the law and the Agreement to protect public health, safety, welfare, or the environment; or to prevent, abate, or minimize a release or threatened release of hazardous substance, pollutants, or contaminants on, at, or from the Facility. Wexford County Landfill, LLC, shall provide access as necessary to the DPW and their contractors to implement the approved RAP.

21. **TERM**: This license shall remain in effect until its expiration date, unless revoked or continued in effect, as provided by, the Administrative Procedures Act, 1969 PA 306, as amended, or unless superseded by the issuance of a subsequent license.

END OF LICENSE



MW-2R-2
MW-10
MW-12
MW-9R
MW-3R
MW-36
MW-11
MW-6
MW-7R
MW-4
FUTURE CELL 1 4.23 ACRES
FUTURE CELL H 11.06 ACRES
FUTURE CELL I 10.73 ACRES
EXISTING OFFICE/SCALE
EXISTING SECONDARY CONTAINMENT
EXISTING LEACHATE STORAGE TANK
EXISTING 20,000 GALLON LEACHATE BACKUP TANK
EXISTING MAINTENANCE BUILDING
FUTURE CELL 1 7.84 ACRES
FUTURE CELL 7 TYPE III INDUSTRIAL
FUTURE CELL 8 TYPE III INDUSTRIAL
FUTURE CELL 9 TYPE III INDUSTRIAL
HWY 131
LEGEND
LANDFILL PROPERTY BOUNDARY
SOLID WASTE BOUNDARY
EXISTING CELL BOUNDARY
FUTURE CELL BOUNDARY
EXISTING DUAL CONTAINED FORCEMAIN
FENCE LINE
PAVED ROAD
UNPAVED ROAD
MW-XX MONITORING WELL
Received WRD/DEQ
JUN
GAYLORD
0 200 400 800
SCALE FEET
REV DATE
PROJECT
WEXFORD COUNTY LANDFILL, LLC.
MANTON, MICHIGAN
TITLE
FACILITY MAP
Golder Associates
PROJECT No 123-88763
FILE No 12388763A060
DESIGN VRG 2013-11-05
SCALE AS-SHOWN
CADD AJK 2013-11-05
ATTACHMENT A
CHECK VRG 2013-11-05
REVIEW SCP 2013-11-05

TABLE 2.
WEXFORD COUNTY LANDFILL
First Quarter 2013 Monitoring Event
Duplicate Sample Data Summary

Constituent	Units	Sample ID MW-8	Duplicate (MW-81)	RPD
Primary Inorganic Indicators				
Boron	µg/L	380	370	2.7
Chloride	µg/L	56,000	57,000	1.8
Potassium	µg/L	18,000	18,000	0.0
Sodium	µg/L	42,000	41,000	2.4
Total Inorganic Nitrogen (TIN)	µg/L	9,900	11,000	10.5

Notes:

RPD = relative percent difference.

Shaded values exceed the acceptable laboratory RPD.

ND = The results were not detected above the detection limit.

TABLE 2.
WEXFORD COUNTY LANDFILL
First Quarter 2014 Monitoring Event
Primary Leachate Collection System Pumping Volumes

Monitoring Point Identification	January 2014 (Gallons)	February 2014 (Gallons)	March 2014 (Gallons)
Cell A	6,474	3,128	4,209
Cell B	102,996	92,101	103,312
Cell C	142,041	91,042	91,422
Cell D & E	326,943	237,848	180,534
Cell F	235,384	179,369	230,710
Cell G	398,423	311,197	453,113
TOTALS	1,212,261	914,685	1,063,300

Notes:

Leachate data reported by Wexford County Landfill personnel and tabulated by Golder.

TABLE 5.
WEXFORD COUNTY LANDFILL
Second Quarter 2013 Monitoring Event
Primary Leachate Collection System Pumping Volumes

Monitoring Point Identification	April 2013 (Gallons)	May 2013 (Gallons)	June 2013 (Gallons)
Cell A	15,203	15,262	5,574
Cell B	141,539	120,462	116,146
Cell C	115,667	128,620	114,234
Cell D & E	327,395	339,754	288,930
Cell F	641,283	578,707	269,899
Cell G	667,776	597,195	584,737
TOTALS	1,908,863	1,780,000	1,379,520

Notes:

Leachate data reported by Wexford County Landfill personnel and tabulated by Golder.

TA ₂:

WEXFORD COUNTY LANDFILL

Second Quarter 2014 Monitoring Event

Primary Leachate Collection System Flow Data

Monitoring Point Identification	April 2014 (Gallons)	May 2014 (Gallons)	June 2014 (Gallons)
Cell A	6,838	2,867	10,925
Cell B	136,513	93,726	89,553
Cell C	121,013	74,961	278,872
Cell D&E	151,742	178,685	160,073
Cell F	161,505	329,062	291,441
Cell G	582,498	596,992	510,693
Cell J	0	693,696	585,789
Totals	1,160,109	1,969,989	1,927,346

Notes:

Leachate data reported by Wexford County Landfill personnel and tabulated by Pescador.

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WEXFORD COUNTY LANDFILL

Third Quarter 2014 Monitoring Event

Primary Leachate Collection System Flow Data

Monitoring Point Identification	July 2014 (Gallons)	August 2014 (Gallons)	September 2014 (Gallons)
Cell A	13,483	0	0
Cell B	79,800	144,459	89,846
Cell C	446,937	272,667	476,385
Cell D&E	72,857	9,003	0
Cell F	221,578	181,303	216,425
Cell G	511,851	297,670	427,568
Cell J	447,064	307,265	535,088
Totals	1,793,570	1,212,367	1,745,312

Notes:

Leachate data reported by Wexford County Landfill personnel and tabulated by Pescador.

TABLE 5:
WEXFORD COUNTY LANDFILL
Fourth Quarter 2014 Monitoring Event
Primary Leachate Collection System Pumping Volumes

Monitoring Point Identification	October 2014 (Gallons)	November 2014 (Gallons)	December 2014 (Gallons)
Cell A	0	19,562	17,976
Cell B	93,182	103,291	111,902
Cell C	512,080	549,646	538,835
Cell D&E	54,290	60,067	245,148
Cell F	246,512	279,621	361,682
Cell G	488,739	460,400	613,231
Cell J	541,103	362,220	517,585
Totals	1,935,906	1,834,807	2,406,359

Notes:
Leachate data reported by Wexford County Landfill personnel and tabulated by Pescador.

Wexford County Landfill

Manton, MI

Monthly Flow Report

Jan-14

Day	Cell A Primary Gallons Pumped	Cell B Primary Gallons Pumped	Cell B Secondary Gallons Pumped	Cell C Primary Gallons Pumped	Cell C Secondary Gallons Pumped	Cell D&E Primary Gallons Pumped	Cell D&E Secondary Gallons Pumped	Cell F Primary Gallons Pumped	Cell F Secondary Gallons Pumped	Cell F [illegible]	Cell G Primary Gallons Pumped	Cell G Secondary Gallons Pumped	Daily Precipitation
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	

[illegible] Precipitation [illegible] Gallons Pumped [illegible]

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G
Action Flow Rate (gal/acre/day)	[illegible]	24	20 [illegible]	41 [illegible]	[illegible]	[illegible]
Current Month Avg. (gal/acre/day)	[illegible]	5.6 [illegible]	3.74	0.67	0.00	0.07
Previous Two Months (gal/acre/day)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate (gal/acre/day)	[illegible]	#REF!	#REF!	#REF!	#REF!	#REF!

[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
Feb 14

	Cell A	Cell B		Cell C		Cell D&E		Cell F			Cell G		
Day	Primary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Daily Recirculation	Primary Gallons Pumped	Secondary Gallons Pumped	Daily Recirculation
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]

[illegible] [illegible] [illegible] Gallons Pumped [illegible]

Action Flow rate (gals/acre/day)		[illegible]	[illegible]	[illegible]	[illegible]	26.8
Current Month Avg. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]
[illegible] Month [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate [illegible]	[illegible]	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

[illegible]

[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
Mar 14

Day	Cell A	Cell B		Cell C		Cell D&E		Cell F			Cell G		
	Primary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Primary Gallons Pumped	Secondary Gallons Pumped	Daily Recirculation	Primary Gallons Pumped	Secondary Gallons Pumped	Daily Recirculation
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] Pumped [illegible]

[illegible]	Cell B	Cell C	Cell D&E	Cell F	Cell G
[illegible]	24.9	29.3	41.8	31.6	26.5
[illegible]	0.50	[illegible]	1.58	4.60	5.16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Flow Rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Wexford County Landfill

Manton, MI

Monthly Flow Report

[illegible]

WINDEMULLER

Day	Cell A	Cell B		Cell C		Cell D&E		Cell F			Cell G			Cell J	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Pumped
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] Gallons Pumped [illegible] Rate [illegible] Gallons Pumped [illegible]

Average Flow Rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Month [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average [illegible] Rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
May-14

WINDEMULLER

Day	Cell A Primary Gallons Pumped	Cell B Primary Gallons Pumped	Cell B Secondary Gallons Pumped	Cell C Primary Gallons Pumped	Cell C Secondary Gallons Pumped	Cell D&E Primary Gallons Pumped	Cell D&E Secondary Gallons Pumped	Cell F Primary Gallons Pumped	Cell F Secondary Gallons Pumped	Cell F Daily Recirculated	Cell G Primary Gallons Pumped	Cell G Secondary Gallons Pumped	Cell G Daily Recirculated	Cell J Primary Gallons Pumped	Cell J Secondary Gallons Pumped
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]			[illegible]	[illegible]

Month's Gallons Pumped [illegible] Recirculation Gallons Pumped

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J
Action Flow rate (gal/acre/day)	[illegible]	24	20.0	45.0	31.5	29.5	20.0
Current Month Avg. (gal/day/acre)	[illegible]	0.60	0.72	0.43	0.00	0.50	0.00
Previous Two Months (gal/day/acre)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	#REF!
Average Daily Flow Rate (gal/day/acre)	[illegible]	0.30	[illegible]	0.43	0.00	0.21	#REF!

[illegible]

[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
Jun-14

WINDEMULLER

Day	Cell A	Cell B		Cell C		Cell D&E		Cell F			Cell G			Cell J	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Gallons Pumped

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
Jul 14

WINDEMULLER

Day	Cell A Primary Gallons Pumped	Cell B Primary Gallons Pumped	Cell B Secondary Gallons Pumped	Cell C Primary Gallons Pumped	Cell C Secondary Gallons Pumped	Cell D&E Primary Gallons Pumped	Cell D&E Secondary Gallons Pumped	Cell F Primary Gallons Pumped	Cell F Secondary Gallons Pumped	Cell F Daily Recirculation	Cell G Primary Gallons Pumped	Cell G Secondary Gallons Pumped	Cell G Daily Recirculation	Cell J Primary Gallons Pumped	Cell J Secondary Gallons Pumped
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Monthly Gallons Pumped [illegible] Recirculation [illegible] Gallons Pumped [illegible]

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J
Action Flow rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Month [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
[illegible] Months [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate [illegible]	[illegible]	[illegible]	1.65	3.30	0.00	1.86	0.00

[illegible]

[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
Aug-14

WINDEMULLER

Day	Cell A	Cell B		Cell C		Cell D&E		Cell F			Cell G			Cell J	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Primary Gallons Pumped	Secondary Gallons Pumped
1–31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]			[illegible]	[illegible]		[illegible]	[illegible]

Quantity ... Gallons Pumped [illegible] Recirculation [illegible] Gallons Pumped [illegible]

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J
Average Flow rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Current Month Avg. (gallons/acre/day)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Previous Two Months Average (gallons/acre/day)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate (gallons/acre/day)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

Wexford County Landfill

Manton, MI

Monthly Flow Report

Sep-14

WINDEMULLER

Day	Cell A Primary Gallons Pumped	Cell B Primary Gallons Pumped	Cell B Secondary Gallons Pumped	Cell C Primary Gallons Pumped	Cell C Secondary Gallons Pumped	Cell D&E Primary Gallons Pumped	Cell D&E Secondary Gallons Pumped	Cell F Primary Gallons Pumped	Cell F Secondary Gallons Pumped	Cell F [illegible]	Cell G Primary Gallons Pumped	Cell G Secondary Gallons Pumped	Cell G [illegible]	Cell J Primary Gallons Pumped	Cell J Secondary Gallons Pumped
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	140
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	264

Monthly [illegible] Pumped [illegible]   Recirculation [illegible]   Gallons Pumped [illegible]

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J
Action Flow rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20.0 [illegible]
[illegible] Month [illegible]	[illegible]	[illegible]	[illegible]	2.21	0.00	0.76	[illegible]
[illegible] Month [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]	20.50

[illegible]

[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
[illegible] 14

WINDEMULLER

Day	Cell A	Cell B		Cell C		Cell D&E		Cell F			Cell G			Cell J	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Primary Gallons Pumped	Secondary Gallons Pumped	Total Recirculated	Primary Gallons Pumped	Secondary Gallons Pumped	Total Recirculated	Primary Gallons Pumped	Secondary Gallons Pumped
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Monthly Gallons Pumped [illegible] Recirculation [illegible] Gallons Pumped [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2.06	5.06	[illegible]	[illegible]
Months [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21.35

[illegible]

Wexford County Landfill

Manton, MI

Monthly Flow Report

Nov-14

WINDEMULLER

Day	Cell A Primary Gallons Pumped	Cell B Primary Gallons Pumped	Cell B Secondary Gallons Pumped	Cell C Primary Gallons Pumped	Cell C Secondary Gallons Pumped	Cell D&E Primary Gallons Pumped	Cell D&E Secondary Gallons Pumped	Cell F Primary Gallons Pumped	Cell F Secondary Gallons Pumped	Cell F Daily Recirculation	Cell G Primary Gallons Pumped	Cell G Secondary Gallons Pumped	Cell G Daily Recirculation	Cell J Primary Gallons Pumped	Cell J Secondary Gallons Pumped
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14,692	0
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,290	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13,167	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,340	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14,674	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13,495	0
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15,036	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14,405	[illegible]	[illegible]	13,825	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13,889	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,430	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	476		[illegible]	[illegible]

Monthly Gallons Pumped [illegible] Recirculation [illegible] Gallons Pumped [illegible]

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J
Action Flow rate (gal/acre/day)	[illegible]	36. [illegible]	[illegible]	41. [illegible]	[illegible]	[illegible]	29.9 [illegible]
Current Month Avg. (gal/day/acre)	[illegible]	[illegible]	3.05	1.27	[illegible]	1.74	1.35
Previous Two Months (gal/day/acre)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate (gal/day/acre)	[illegible]	[illegible]	[illegible]	2.05	[illegible]	1.26	2.39

[illegible]

[illegible]

Wexford County Landfill
Manton, MI
Monthly Flow Report
Dec-14

WINDEMULLER

Day	Cell A Primary Gallons Pumped	Cell B Primary Gallons Pumped	Cell B Secondary Gallons Pumped	Cell C Primary Gallons Pumped	Cell C Secondary Gallons Pumped	Cell D&E Primary Gallons Pumped	Cell D&E Secondary Gallons Pumped	Cell F Primary Gallons Pumped	Cell F Secondary Gallons Pumped	Cell F Daily Recirculation	Cell G Primary Gallons Pumped	Cell G Secondary Gallons Pumped	Cell G Daily Recirculation	Cell J Primary Gallons Pumped	Cell J Secondary Gallons Pumped
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	0
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14,132	[illegible]	0	[illegible]	[illegible]		[illegible]	0
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]		[illegible]	0
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		14,725	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,076	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		25,249	0
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]		[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	0
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]		[illegible]	0
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	0
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]		[illegible]	0
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]		[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		19,722	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		17,157	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	0
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	149

Monthly Gallons Pumped [illegible] Recirculation [illegible] Gallons Pumped 0

	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J
Action Flow rate (5 gal/acre/day)	[illegible]	[illegible]	20.8	[illegible]	31.5	[illegible]	20.0
Current Month Avg (gal/day/acre)	[illegible]	[illegible]	[illegible]	[illegible]	0.69	2.53	1.26
Previous Two Months (gal/day/acre)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average Daily Flow Rate (gal/day/acre)	[illegible]	[illegible]	[illegible]	1.74	[illegible]	1.84	[illegible]

[illegible]

[illegible]

WEXFORD COUNTY LANDFILL
Primary Leachate Collection System Pumping Volumes

Year		Primary Monthly Gallons Pumps								
	Cell ID	Cell A	Cell B	Cell C	Cell D&E	Cell F	Cell G	Cell J	Cell G3	Total
	Acreage	6	4.8	4	8.2	6.3	9.9	4.23	6.7	50.13
2008		336,071	1,379,103	1,959,105	4,542,543	4,108,510	4,561,098	0	0	16,886,430
2009		195,617	1,470,828	1,895,057	4,395,344	3,402,944	5,512,189	0	0	16,871,979
2010		169,449	1,159,432	1,296,617	2,866,464	2,194,775	2,311,884	0	0	9,998,621
2011		189,195	1,214,581	1,227,695	2,715,930	2,143,771	2,936,032	0	0	10,427,204
2012		108,131	1,527,267	1,503,857	3,657,255	2,209,479	2,923,253	0	0	11,929,242
2013		82,139	1,180,004	1,051,630	2,673,998	3,164,709	5,141,725	0	0	13,294,205
2014		85,462	1,240,681	3,595,901	1,676,515	2,944,045	5,697,325	4,074,664	0	19,314,593
2015		156,183	941,657	3,201,671	1,135,465	2,769,282	3,718,983	2,522,200	918,623	15,364,064
2016		202,660	1,016,508	3,630,656	2,410,177	3,533,685	5,287,687	4,380,280	3,737,286	24,198,939

2.I FORMATION TESTING PROGRAM

Describe the proposed formation testing program. For Class I wells the program must be designed to obtain data on fluid pressure, temperature, fracture pressure, other physical, chemical, and radiological characteristics of the injection matrix and physical and chemical characteristics of the formation fluids.

Response:

The WWT Disposal Well No. 1 is expected to be installed and tested in the year 2017 or 2018 according to applicable regulations and permit requirements. Static pressure testing of the Traverse and Dundee or any comingled sub-Detroit River formations completed will be performed, along with determination of various injection interval characteristics such as permeability-thickness, which would be determined via pressure transient testing. Injection formation native brine chemistry and characteristics will be determined based by acquisition of a fluid sample. Characteristics of the injection interval will also be evaluated based on geophysical well logging results. Additional details regarding the well logging are presented in Response 2.L, construction details.

Based on equipment availability, prior to conducting any injection testing, injection interval fluid will be produced from a targeted injection formation using either a submersible pump or swabbing equipment. Based on fluid loss during drilling and field conditions, target production volumes for obtaining representative samples will be adjusted in the field, based on conditions encountered. Field parameters including pH and conductivity will also be monitored at surface as fluid is recovered to determine when representative sampling is practical. Injection Zone formation fluid will be subjected to analysis for the following parameters:

- Alkalinity, Arsenic, Barium, Bicarbonate, Cadmium, Calcium, Carbonate, Chloride, Chromium, Conductivity, Copper, Hardness, Iron, Lead, Magnesium, Manganese, Molybdenum, Nickel, Nitrate, as (N), pH, Potassium, Radium 226, Radium 228, Selenium, Silica as $SiO2$, Sodium, Specific Gravity, Strontium, Sulfur, TDS, TSS, Zinc.

Annual Part I mechanical integrity testing for the WWT Well No. 1 will include reservoir monitoring as specified in 40 CFR 146.13 (d) in addition to static annulus pressure testing. WWT will provide the agency a minimum of 30 days notice prior to annual testing. Although test procedures or methods may be changed based on approval by Region 5 USEPA staff, the following procedure will be used for the first such testing performed:

1. Conduct Wellsite Safety Meeting
   A. Prior to commencement of field activities, conduct safety meeting with contractors and personnel to be involved with field services and MIT testing. Ensure that all safety procedures are understood and review

days work activities.

2. Conduct Fall-Off Test
   A. Record data regarding test well injection at typical operating conditions (constant rate). Rate versus time data will be recorded during the injection period. Cumulative volume injected will also be recorded. Continue injection for a minimum of approximately five hours. Additional time may be required depending on the nature of formation characteristics estimated from fluid sampling activities. Note that significant rate variations may yield poor quality data or require more complicated analysis techniques.
   B. Rig-up pressure gauge.
   C. Obtain final stabilized injection pressure for a minimum of one hour. Ensure that the gauge temperature readings have also stabilized.
   D. After gauge recordings are stable, cease injection and monitor pressure fall-off. Instantaneous shut-in yields best results. Continue monitoring pressure for a minimum of four hours or until a valid observation of fall-off curve is observed.
   E. Stop test data acquisition, rig-down and release equipment.

3. Annulus Pressure Test
   A. Stabilize well pressure and temperature.
   B. Arrangements will be made for a representative from the USEPA to be present to witness this testing.
   C. Install ball valve or similar type "bleed" valve on annulus gate valve. Pressurize annulus to a minimum of 100 psig with liquid and shut-in pump side gate valve. If typical operating annulus pressures are above 100 psi, higher pressures acceptable to the agency and compatible with the well completion configuration will be utilized in this testing. Pressure to be used will be detailed in proposed procedures supplied with notification of testing. Install USEPA-certified gauge on "bleed" type valve. The annulus may need to be pressurized and bled off several times to ensure an absence of air. Monitor and record pressure for one hour. Pressure may not fluctuate more than 3 percent during the one-hour test. At the conclusion of the test, lower the annulus pressure to normal operating pressure.

2.J STIMULATION PROGRAM

Outline any proposed stimulation program.

Response:

No specific stimulation program is currently scheduled for the WWT Well No. 1. Historically, jetting and acid treatments have been used to restore injection capacity in Traverse, Dundee and other injection intervals. If necessary to maintain desired injectivity, mechanical well clean-out or acidization may be conducted to reduce injection pressures. The EPA and MDEQ will be notified prior to any stimulation activities being conducted in the well.

2.K INJECTION PROCEDURES

Describe the proposed injection procedures including pump, surge tank, etc.

Response:

The WWT Well No. 1 will be installed within the Wexford County Landfill property boundary. The Wexford County Landfill facility is located approximately 5 1/2 miles south of Manton, Michigan on Highway 131, T23N R9W Sections 33 and 34. The landfill cells and associated primary and secondary leachate collection systems are located within the property footprint as shown in Figure K-1. The injection well annulus equipment pumps and the wellhead will be located in an enclosed building adjacent to the Leachate Collection Tank or the well. A flow chart drawing of the major surface facility components is included in this response as Figure K-2.

As previously indicated in this document, wastewater intended for injection is to be obtained from the active landfill cells leachate collection systems. Wastewater is collected from each cell by pump and transferred to the leachate collection tank through a dedicated double-walled forcemain where the leachate from cells is comingled. Injectate may also be transferred to the central collection by truck and will be piped from the Leachate Tank to the injection equipment and the wellhead.

Operators will manually start the injection process by powering the pumps and opening necessary valves. In addition to monitoring by an operator, engineering restraints have been incorporated in the well monitoring system (WMS) to meet current UIC regulations and anticipated permit conditions. This system will be in place at all times and functional when the well is operating. These systems will include Murphy switches or electronic controls so that in event of a disruption of differential pressure, the WMS will activate an alarm and stop the injection of fluids. Operators will be required to monitor the alarm system regularly during operations. A high injection pressure switch will shut-in the well and/or shut off the injection pump and activate an alarm if the maximum allowable injection pressure is exceeded.

Annulus pressure in the system will be maintained with a nitrogen blanket supplied from pressurized nitrogen cylinders. In the event of power failure, positive pressure can then still be maintained on the annulus. If any of the applicable permit conditions are exceeded, including injection pressure and differential pressure an alarm will sound and the injection operations will cease until the problem is identified, corrected and the system manually restarted.

If the proposed WWT Well No. 1 is monitored and operated remotely, the following special conditions shall be applicable. For the purpose of this permit, remote monitoring is defined as injection into the well when a trained operator is not present on site property and able to perceive shut-down alarms and able to physically respond to the well controls or the wellhead within 15 minutes of a compliance alarm condition.

1. Local operating system and remote monitoring system: If remote monitoring is to be used to operate the well, an automatic pager shall be onsite and designed to alert designated on-call, off-site personnel in the event of a well alarm or shut-in and equipped with a back-up power supply.

2. Response to automatic shut-downs: Alarm shut-downs of the operating well related to permit compliance conditions of the well under Part II (B) (5) shall be investigated on-site by a trained operator within one (1) hour of pager notification of the occurrence.

3. Loss of power to the control system: In the event a power failure beyond the capability of the back-up power supply shuts down the control system, the well shall be shut-in.

4. Loss of dial tone: If the automatic pager cannot get a dial tone for 30 minutes, the well shall automatically be shut-in.

5. Restart of the well after an automatic shut-in: Restart of the well after a shut-in related to a permit condition alarm (including, but not limited to, injection pressure, annulus differential pressure, loss of dial tone for more than 30 minutes or control system power failure) shall require the physical presence of the operator on-site before the well can be restarted.

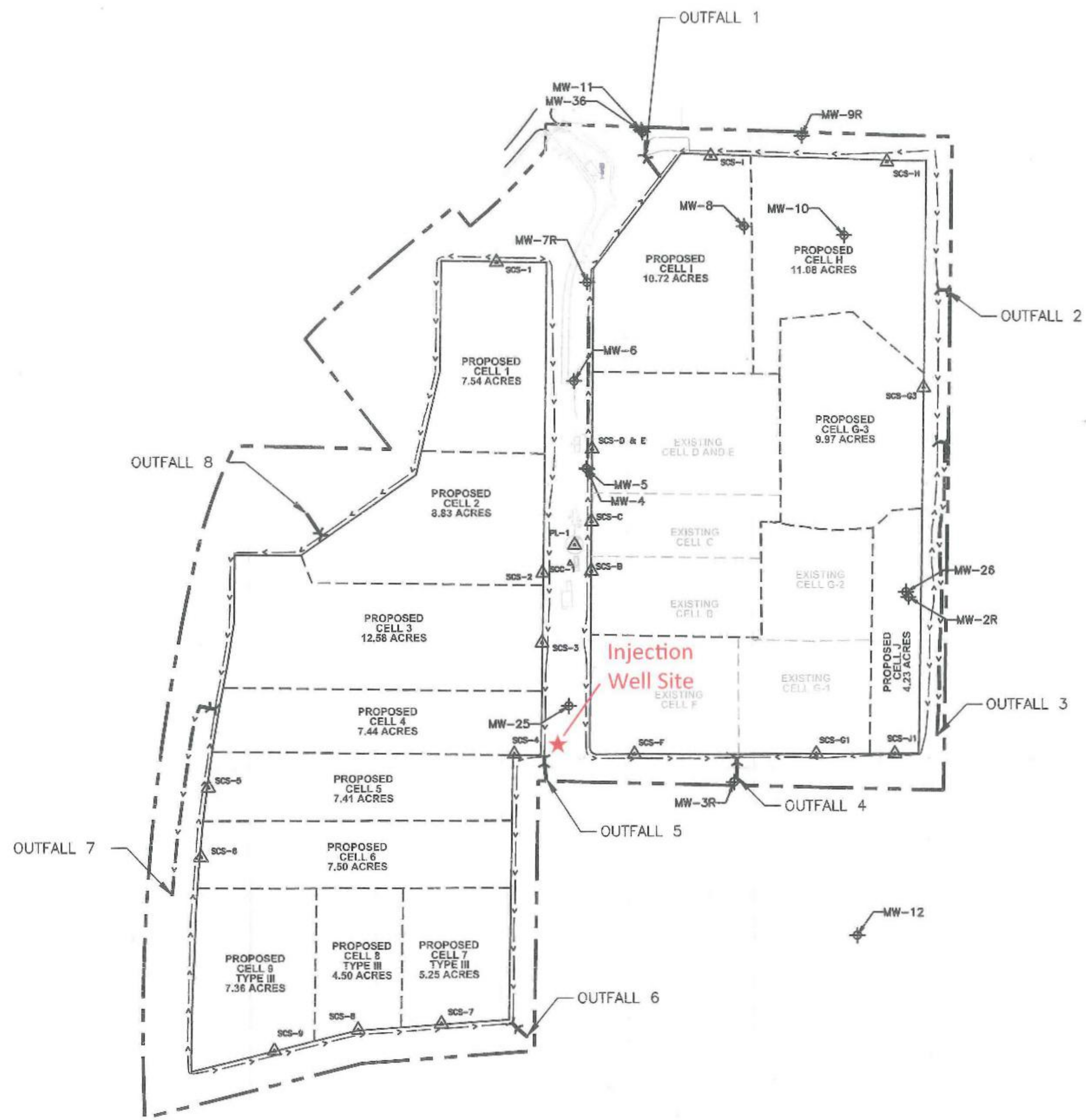
6. Restart of the well after non-permit condition related or scheduled shut-ins: If the well is shut-in for more than 48 hours for circumstances unrelated to permit conditions, restart of the well shall require the physical presence of the operator on-site.

7. Weekly operator inspections: If fluid injection occurs during the period of any week and the well is being monitored remotely, a trained operator shall physically visit the site to inspect the facility at a minimum frequency of not less than once per week. This inspection shall verify the correct operation of the remote monitoring system by review of items such as, but not limited to, a comparison of the values shown on mechanical gauges with those reported by the remote operating system. Unless annulus pressure changes by more than 10 percent per week while the well is injecting, only one annulus fluid level per week shall be required to be taken, recorded and reported when injection takes place.

8. When the well is not actively being used for injection, one annulus tank fluid level measurement shall be taken, recorded and reported per week unless

annulus fluid pressure decreases more than 10 percent per week. In such cases of increased annulus pressure change, annulus fluid level measurements shall be taken, recorded and reported twice per week.

9. When not in use by a trained well operator, offloading connections shall be secured and shall be locked at the valves leading to waste water tank so that access is restricted to trained well operators.



LEGEND

	PROPERTY BOUNDARY
	SOLID WASTE BOUNDARY
MW-XXX	MONITORING WELL LOCATION
XXX	LEACHATE/SECONDARY SAMPLING LOCATION
XXX	SECONDARY CONTAINMENT

NOTE

1. HORIZONTAL GRID SYSTEM IS BASED ON A SITE SPECIFIC LOCAL GRID.

From: Golder Associates, 2012

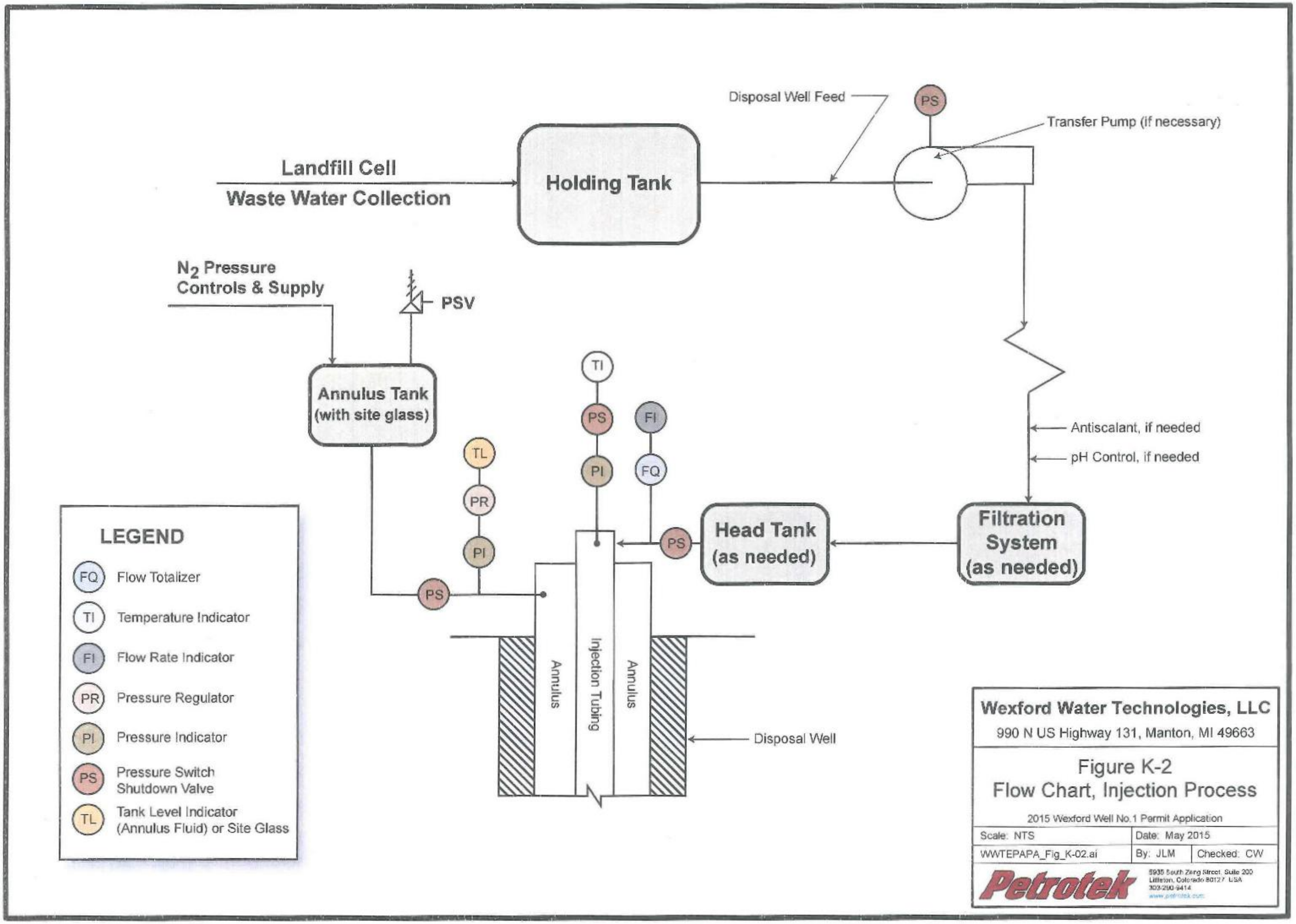
Wexford Water Technologies, LLC
990 N US Highway 131, Manton, MI 49663

Figure K-1
Surface Facility Diagram showing Landfill Cells and Property Footprint

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 5/2015 Rev. 8/2016
WWTEPAPA_Fig_K-01.ai	By: JLM / Checked: CW

Petrotek
5935 South Zang Street, Suite 200
Littleton, Colorado 80127 USA
303-290-9414
www.petrotek.com



Wexford Water Technologies, LLC

990 N US Highway 131, Manton, MI 49663

Figure K-2
Flow Chart, Injection Process

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: May 2015
WWTEPAPA_Fig_K-02.ai	By: JLM / Checked: CW

Petrotek
5935 South Zang Street, Suite 200
Littleton, Colorado 80127 USA
303-290-9414
www.petrotek.com

2.L CONSTRUCTION PROCEDURES

Discuss the construction procedures (according to §146.12 for Class I, §146.22 for Class II, and §146.32 for Class III) to be utilized. This should include details of the casing and cementing program, logging procedures, deviation checks, and the drilling, testing and coring programs, and proposed annulus fluid. (Request and submission of justifying data must be made to use an alternative to a packer for Class I.)

Response:

The proposed WWT Well No. 1 will be installed upon approval of the required EPA and MDEQ permits per the following procedures and specifications. Figure M-1, M-1a, M-2 and K-1 provide a graphical summary of proposed well and equipment to be installed. A primary well design is presented for completion of the well as a Traverse/Dundee injector, and supplemental information is presented for optional deeper completion if insufficient capacity is found in proposed Traverse/Dundee injection intervals.

Well construction will take place on the current municipal landfill site. No tree clearing will occur as part of the well construction. The access road is pre-existing.

SUBSURFACE

Upon preparation of the site and mobilization of required equipment, 20" conductor casing, will be driven to approximately 80 feet. If driven casing is not practical due to equipment availability or other factors, the 20-inch, 94 lb/ft, H-40 grade, ST&C, or suitable equivalent will be cemented to surface in a 26" borehole to an anticipated depth of approximately 80 feet BGL. If a gauge borehole diameter is assumed and 20% excess cement is assumed, approximately 130 sx of 1.18 cuft/sx yield Michigan equivalent Class A cement with additives or suitable equivalent would be utilized to cement the string to surface. Site specific conditions will be used to further refine cement volume. After the conductor pipe is installed, a rotary rig will be mobilized to the location, and a 17 1/2 inch hole will be drilled out of the conductor casing to a depth of approximately 370 feet.

The hole will then be conditioned and 13-3/8", 54.5 lb/ft J-55, ST&C, or suitable equivalent surface casing will be installed from surface to a depth of approximately 370 feet. The base of the clay will not be penetrated. The cementing program will be determined based on field conditions, but at a minimum will consist of a mixture of Michigan equivalent Class A standard cement with additives or a suitable equivalent. Excess cement (up to 75% of the calculated volume) will be available and may be used based on measured hole conditions. It is anticipated that a float shoe will be used with a float collar located one joint off bottom, and that centralizers will be placed at a minimum of one every fifth joint.

A 12-1/4" borehole will then be drilled out of surface casing to a depth of approximately

1,600'. Confirmation of the base of underground source of drinking water (USDW) will be conducted via geophysical well logging to verify that the USDW (<10,000 mg/l total dissolved solids) is in the Saginaw/Michigan formation (depth of approximately 810' – 890'). If required due to inconclusive logging, or at the request of MDEQ or EPA, a confirmatory fluid sample may be taken via DST (drill stem test) from the Marshall or other units (depths of approximately 1,400' – 1,600'). Well design will isolate both the Saginaw/Michigan and Marshall formations behind two casing strings. The DST assembly would be run on the end of the drill pipe into the open hole section and an expandable packer would seal the zone of interest from other exposed intervals. Fluid from the zone of interest would then be produced into the tool and the drill string, and removed from the hole for analysis.

After the openhole logging/testing program is completed, the hole will be conditioned and 9-5/8", 36 lb/ft, J-55, ST&C, or equivalent suitable casing will be installed from surface to a depth of approximately 1600'. The casing shoe will be targeted at a minimum of 100 feet below the base of the lowermost USDW. The cementing program will be determined based on field conditions, but at a minimum will consist of a mixture of Michigan equivalent Class A standard cement with additives or a suitable equivalent. Excess cement (up to 75% of the calculated volume) will be available and may be used based on measured hole conditions. It is anticipated that a float shoe will be used with a float collar located one joint off bottom, and that centralizers will be placed at a minimum of one every fifth joint.

After the surface casing string has been cemented and a minimum of 24 hours waiting on cement (WOC) time has elapsed, remaining cement will be drilled out of the surface casing string shoe and an 8 3/4-inch hole will then drilled to a depth of approximately 4,050 feet BGL through the base of the Dundee Formation and into the top of the Detroit River. The primary targeted injection interval will be penetrated during this stage of the drilling process. A cement bond log will be conducted to document cement circulation in the surface casing. It is projected that after the first phase of the deep openhole logging program is complete (see Table L-1, Section 2.L), the hole will be conditioned and 7-inch, 26 lb/ft, J-55, ST&C, or suitable equivalent long-string casing will be installed to a depth of approximately 4,050 feet. The cementing program for the long string will be determined based on field conditions, but will likely consist of a mixture of Michigan equivalent Class A standard cement with additives or suitable equivalent. Depending on hole conditions and geologic considerations, light-weight cement and/or a two-stage cement job utilizing a DV tool may be utilized. Additional excess cement, if any, will be pumped based on field conditions. It is anticipated that a float shoe will be used with a float collar one joint up from the bottom and that centralizers are to be placed a minimum of one every fifth joint. A cement bond log will be run at some time during completion activities to evaluate the 7" long-string cement job.

The potential injection capacity of the Dundee formation will then be evaluated by review of logging data, drilling data, and possible openhole test data. If required, the long-string casing may be perforated at this time to perform additional testing. If test fluid is to be injected, an original pressure and fluid sample of the Dundee will be obtained prior to test injection. A drill stem test (DST) during drilling, downhole sampling, or fluid swabbing will then be conducted to obtain a sample of injection interval fluids. If insufficient capacity is determined to exist, the potential injection capacity of the Traverse formation will then be evaluated by review of logging data, drilling data, and possible openhole test data. A drill stem test (DST) during drilling, downhole sampling, or fluid swabbing will then be conducted to obtain a sample of injection interval fluids. If required, the long-string casing may be perforated at this time to perform additional testing. If test fluid is to be injected, an original pressure and fluid sample of the Traverse will be obtained prior to test injection. If neither formation is suitable for injection, the hole will be deepened. A Traverse/Dundee well completion is presented in Figure M-1a.

If deeper, alternate injection zone targets are pursued, the Traverse and Dundee perforations may be squeezed if deemed necessary based on testing. Shoe cement will then be drilled out of the 7" casing and the well will be deepened using a 6" or 6 ⅛" bit to a depth of up to approximately 6,000 ft, or to the base of the required injection zone (i.e. Detroit River, Amherstburg, Sylvania, Bois Blanc, and/or Bass Islands). If sufficient injection zone thickness is encountered based on lost circulation, drilling may be stopped prior to reaching maximum total depth. After drilling is completed, additional openhole logging will be conducted to obtain data regarding the injection interval. A drill stem test (DST) during drilling, downhole sampling, or fluid swabbing will be conducted to obtain a sample of commingled deep injection interval fluids.

Depending on conditions encountered in the well, the well may remain as an openhole completion below the base of the Detroit River salts, with a 5" 18.0 lb/ft N-80 production liner run from inside the 7" long string casing to a depth required to maintain hole conditions. At a minimum, the liner will isolate the base of the Detroit River Salts. If a liner is deemed necessary, an under-reamer or hole opener will be run to increase hole size to 6 1/2" prior to running the liner. A maximum configuration of a cemented liner from 3,000 feet to 6,000 feet is shown on Figure M-1b, but the liner may terminate below the Detroit River salts, with the remained of the well completed openhole since all formations from the Traverse through TD are the requested injection zone. Depending on formation and hole conditions, the liner may be secured in the 7" casing with a liner hanger, and not cemented. Decisions regarding well configuration below the top of the Traverse Limestone injection zone are considered operational issues rather than mechanical integrity issues and will be determined on-site based on well-specific conditions encountered. A cement bond log and baseline casing inspection log will be conducted in the long string casing, and a directional survey will be conducted to ascertain the bootom hole location and trajectory of the well.

A packer will be set at a depth of approximately 3,000 feet inside the 7-inch long string casing if the well is completed in the primary target Traverse and/or Dundee Formations. If the well is deepened and a cemented liner is run below 3,000 feet, the packer may be set at this depth, or may be set deeper inside the liner at a depth of up to 5,000 feet based on the final permit-authorized top of injection interval. Depending on well capacity and completion depth 2-7/8", 3-1/2" or 4-1/2" coated or lined injection tubing is proposed for the completion. As appropriate, coated or lined tubing and packer may be used to manage potential corrosion issues. A radioactive tracer survey and a temperature log will then be conducted to establish baseline conditions and to demonstrate initial external mechanical integrity. A pressure transient test will also be conducted to derive estimates of formation pressure and properties (See Response 2.I). A proposed schematic for the most probable Wexford County Landfill Well No. 1 completion is presented as Figure M-1a with Figure M-1b presented as the most sophisticated deep completion that may be pursued to use secondary, deeper injection targets. It is possible that completion will not be necessary in progressively deeper zones if sufficient injection capacity is identified, for example, in the Amherstburg. In this case, drilling will terminate at the base of the optimal injection zone, and the well TD will be modified to the base of the subject formation. All other aspects of the well completion will remain as specified in one of the options presented in the application and a modified well construction diagram will be provided to MDEQ for review and approval.

TABLE L-1 LIST OF PROPOSED LOGS WWT WELL NO. 1

Description	Estimated Depth Run
Cement Bond Log	Surf - 370 feet BGS
Dual Laterolog Gamma Ray, Formation Density, and Caliper Logs	1,600 - 370 feet BGS
Cement Bond Log (surface casing liner, if run)	1,600 - 370 feet BGS
Dual LaterLog, SP, Gamma Ray, Formation Density, Compensated Neutron, and Caliper Log	Base of surface casing-TD (base of Dundee OR base of Bass Islands)
Fracture Finder ID Log	Potential injection interval to 100' above injection interval
Cement Bond Log, Casing Inspection Log and Directional Survey	Long string shoe to surface

Figures M-1a and M-1b present the wellbore diagrams for the primary and alternate well construction plans. As shown in these diagrams, each wellbore configuration will require an identical cementing plan up to and including the liner cement job. The cement used for all cement jobs will be Michigan equivalent type A cement. 2% bentonite with 2% $CaCl_2$ accelerator may be required depending on field conditions. Assuming no bentonite or additives, the water requirements will be 5.2 gallons/sack with a minimum slurry yield of 1.18 ft^3/sack. Any casing shoe tests will be run at values conservatively estimated to be below fracture pressure. At a depth of 370 feet, assuming a bottomhole gradient not to exceed 0.7 psi/ft and a normally pressured formation at the shoe, a dp of less than 82 psi would be applied to the casing shoe. At a depth of 1,600 feet, assuming a bottomhole gradient not to exceed 0.7 psi/ft and a normally pressured formation at the shoe, a dp of less than 427 psi would be applied to the casing shoe. At a depth of 4,050 feet, assuming a bottomhole gradient not to exceed 0.7 psi/ft and a normally pressured formation at the shoe, a dp of less than 1,081 psi would be applied to the casing shoe. As noted by Bourgouyne, et. al (1991), the exact amount of compressive strength needed before drilling activites can countinue is difficult to determine, but a value of 500 psi is commonly used in field practice. Compressive strengths that exceed projected test pressures for the proposed cements blends over the range of temperatures expected (60 to 80 degrees Fahrenheit) conservatively referenced at atmospheric pressure are given in the following table:

Time (Hours)	Class A 60°F Compressive Strength (psi)	Class A 80°F Compressive Strength (psi)	2% Bentonite 60°F with 2% CaCl Compressive Strength (psi)	2% Bentonite 80°F with 2% CaCl Compressive Strength (psi)
8	20	265	135	620
12	80	580	255	1,150
24	615	1,905	765	1,820
36*	1,087*	2,823*	1,420*	--
72	2,050	4,125	--	--

*extrapolated

Hole Diameter (in)	Casing Size (OD, in)	Depth (ft)	Cement Volume (sacks)	Approximate Excess Cement (%)	Cement Class (API)	Cement Yield (ft^3/sk)
26	20	80	130*	25%	A	1.18
17.5	13.375	370	420	75%	A	1.18
12.25	9.625	1,600	550	25%	A	1.18
8.75	7	4,050	675	25%	A	1.18
6.5	5	6,000	300**	25%	A	1.18

* Optional if conductor casing is driven
** Cement not applicable below Detroit River salts and Anhydrite if open hole.

If the alternate well configuration is used to target deeper injection zones (Figure M-1b), the 5" liner will be installed from a depth of 3,000' to a maximum of 6,000'. With the full installation, the liner cement job will require 300 sacks, assuming 25% excess pumped. As previously indicated, the liner depth may be terminated at a shallower depth for a smaller thickness completion or open hole completion below the liner.

Unexpectedly high permeability or low reservoir pressure may require two cement stages for a particular cement job; in this case a DV tool may be utilized. At this point it is foreseen that each cement job will be completed in a single stage.

WELLHEAD

The wellhead will consist of a standard Barton 7" slip-on weld casing head or suitable equivalent. The wellhead will include required tubing hanger, slips, and pack-off which will act as the upper seal to the casing-tubing annulus. There will be two, 2" welded NPT nipples for access to the annulus. Annulus fluid will be added through a 2" gate valve and annulus sampling will be conducted opposite the annulus valve. The flow-line will be connected to a gate valve, which will be coupled to a reducing tee. The tee will also have a valve tap to allow wellhead waste sampling, and the top of the tee will be capped with a removable plug.

The system will be fed from the leachate holding tank. This tank will be connected to an injection pump as may be required based on capacity of the completed injection intervals.

ANNULUS SYSTEM

The well will have a positive annulus pressure operating and monitoring system and an interlock system to prevent the well from being operated if permit conditions are exceeded or if unsafe conditions exist. Several operating systems will have preset limits, which can be adjusted depending upon specific operating conditions and reporting requirements. This will allow WWT to maintain compliance with the Class I permit and 40.CFR.146 regulations dictating that the annulus pressure must exceed the injection pressure throughout the length of the wellbore at all times. With a positive annulus pressure, annulus fluid will enter into the injection tubing rather than the waste fluids into the annulus in the event of a system upset.

The annulus pressure system will consist of an upright annulus fluid tank that will be connected to a regulator with nitrogen and/or argon bottles as a pressure source. In the event of power failure, positive pressure will still be maintained on the annulus. The annulus tank will have sufficient reservoir capacity to accommodate the anticipated volume fluctuations due to temperature and pressure limitations.

A two track recorder will record the annulus pressure and injection pressure. A third recorder track will be used to record injection flow rate. Pressure transducers will be located in appropriate taps near the wellhead to measure pressures. Flow rate will be measured using a turbine meter and totalizer or suitable equivalent. Well operators will visually inspect the recorders on a daily basis to ensure proper operation. Murphy switches or electronic devices will be present at the wellhead to set off alarms if pre-set conditions are met. A sight glass or electronic level indicator will be present on the annulus tank level to allow annulus oil inspection by the well operators. The electronic data collection system will be used to digitally record injection pressure, annulus pressure, and flow rate on a minimum frequency of not less than once every minute.

Although the specific shut-down points for the switches and alarm system are not permit conditions, the system will be set to stop the injection pump and set off the alarm if injection pressure reaches a high level of approximately 15 psi below the permitted pressure, or if annulus pressure differential reaches a low value of 120 psi. Loss of annulus fluid will be manually observed and pump power shut-off will be required to terminate injection operations due to fluid loss.

Nature of Annulus Fluid

In the proposed well, the annulus space between the injection tubing and the well protection casing will be sealed and filled with fresh water containing a corrosion inhibitor, an oxygen scavenger and a biocide. Annulus fluids may include Baker Petrolite CRW0037F or Unichem Technihib 366W corrosion inhibitors and bactericides, CRW 132 oxygen scavenger A-303 corrosion inhibitor, Knockout 50 oxygen scavenger, and Bacban 3 Biocides or suitable equivalents. No permit conditions regarding specific brands or fluid additives are requested at this time

References:

Bourgouyne, A.T., Martin E. Chenevert, Keith K. Millheim, F.S. Young, Jr., 1991, Applied Drilling Engineering, SPE Textbook Serios Volume 2

2.M CONSTRUCTION DETAILS

Submit schematic or other appropriate drawings of the surface and subsurface construction details of the well.

Response:

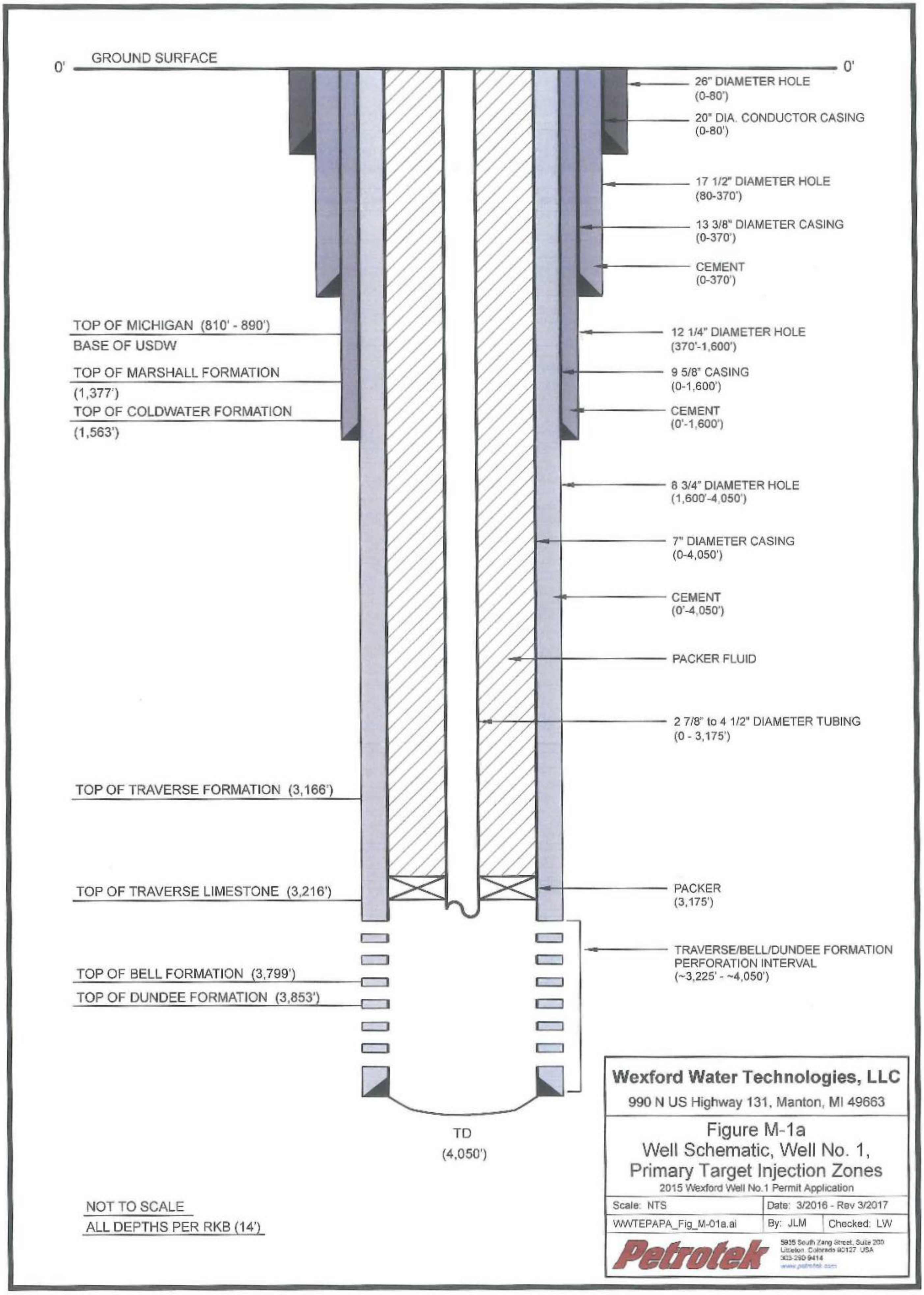
SUBSURFACE WELL CONSTRUCTION DIAGRAMS

The following Form 7520-9 is the completion form for WWT Well No. 1 that will be finalized and provided to EPA when the well has been drilled. Figures M-1a and M-1b illustrating the anticipated completion configurations of the well is also included. Figure M-1a shows the configuration if the primary target (Travers and/or Dundee) is completed for injection. Figure M-1b presents an alternative well construction if the upper target zones are not suitable for injection, and deeper zones (i.e. Amherstburg, Sylvania, Bois Blanc, and/or Bass Islands) are completed for injection.

SURFACE WELL CONSTRUCTION DIAGRAMS

Figures M-1a, M-1b and K-1 are presented that document the anticipated wellhead and annulus system to be used during injection operations.

Additional details regarding proposed construction are provided in Section 2.L of this document.



Wexford Water Technologies, LLC

990 N US Highway 131, Manton, MI 49663

Figure M-1a
Well Schematic, Well No. 1,
Primary Target Injection Zones
2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 3/2016 - Rev 3/2017
WWTEPAPA_Fig_M-01a.ai	By: JLM Checked: LW

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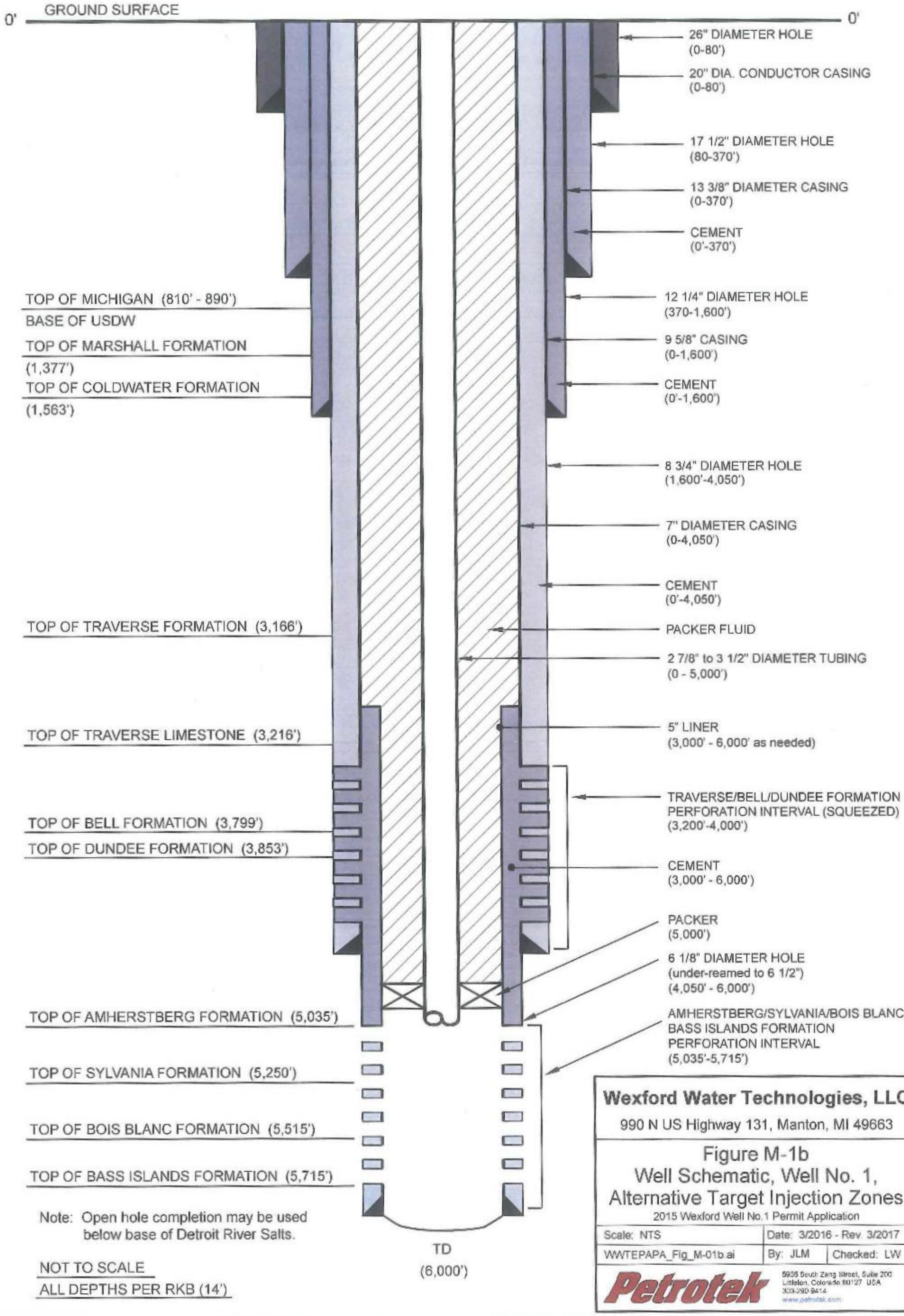
5935 South Zang Street, Suite 200
Littleton, Colorado 80127 USA
303-290-9414
www.petrotek.com



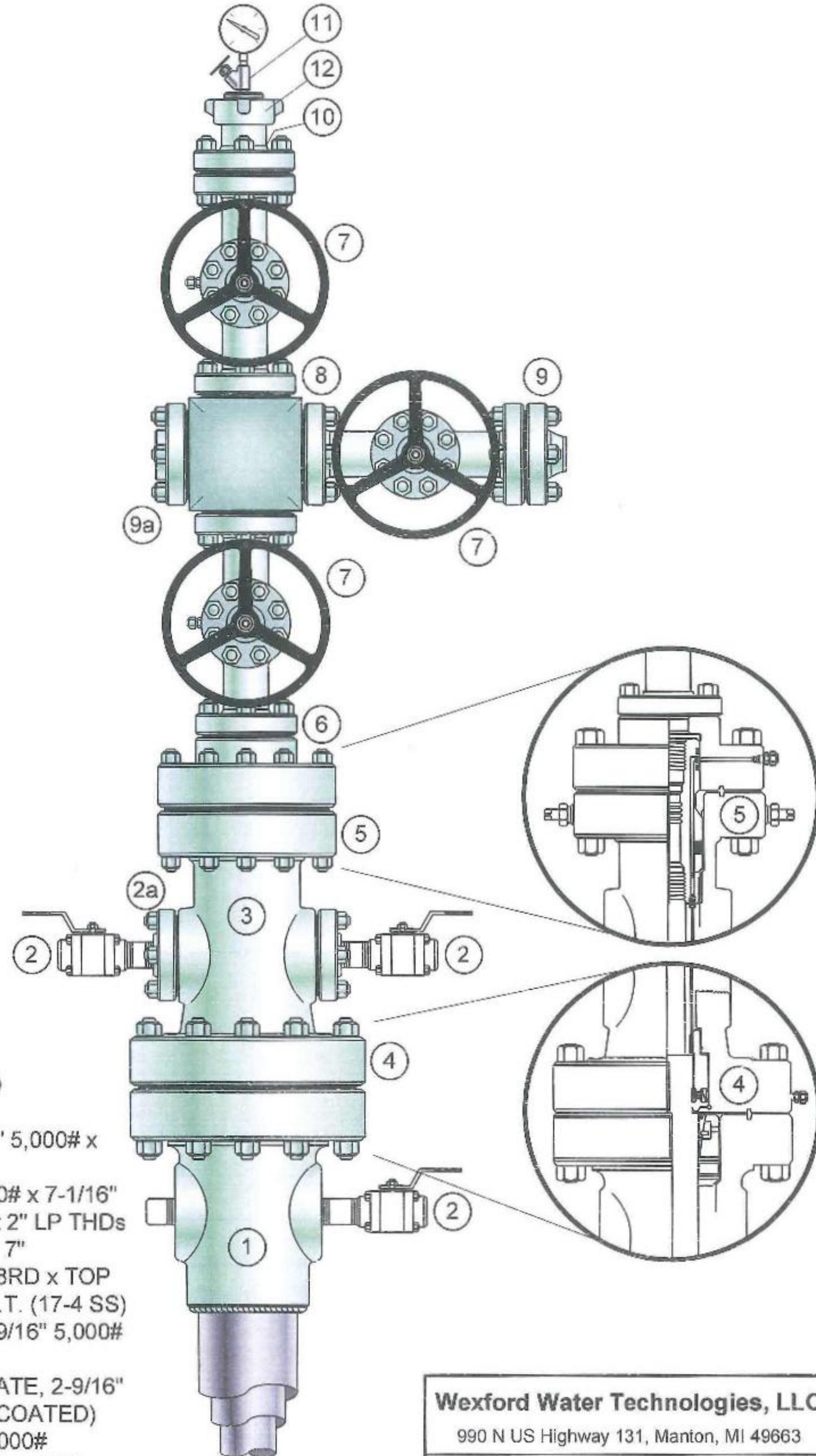
Wexford Water Technologies, LLC

990 N US Highway 131, Manton, MI 49663

Figure M-1b
Well Schematic, Well No. 1,
Alternative Target Injection Zones
2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: 3/2016 - Rev. 3/2017
WWTEPAPA_Fig_M-01b.ai	By: JLM / Checked: LW

Petrotek 5935 South Zang Street, Suite 200 Littleton, Colorado 80127 USA 303-290-9414 www.petrotek.com



1. CASING HEAD, C-22, 11" 5,000# x 9-5/8" SOW W/2" LPO
2. BALL VALVE, 2" LP X 5,000#

2a. COMPANION FLANGE, 2-1/16" 5,000# x 2" LPO

3. TUBING HEAD, TCM, 11" 5,000# x 7-1/16" 5,000# w/2-1/16" 5,000# SSO x 2" LP THDs
4. CASING HANGER, C-22, 11" x 7"
5. TUBING HANGER, 7" x 2-7/8" 8RD x TOP and - BOTTOM w/ 2-1/2" B.P.V.T. (17-4 SS)
6. ADAPTER, 7-1/16" 5,000# x 2-9/16" 5,000# (XYLAN COATED).
7. GATE VALVE, EXPANDING GATE, 2-9/16" 5,000# WP (EE TRIM, XYLAN COATED)
8. CROSS, STUDDED, 2-9/16" 5,000#
9. COMPANION FLANGE, 2-9/16" 5,000# x 2-7/8" EUE (XYLAN COATED)

9a. BLIND FLANGE, 2-9/16" 5,000#

10. 2-9/16" 5,000#
11. NEEDLE VALVE, 1/2" NPT (MFS,MFA)
12. BHTA/TREE CAP w/ 2-7/8" EUE

Note: Suitable equivalents may be used.

Wexford Water Technologies, LLC

990 N US Highway 131, Manton, MI 49663

Figure M-2
Wellhead and
Annulus System Diagram

2015 Wexford Well No.1 Permit Application

Scale: NTS	Date: August 2015	
WWTEPAPA_Fig_M-02.ai	By: JLM	Checked: CW

Petrotek
5935 South Zang Street, Suite 200
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OMB No. 2040-0042 Approval Expires 11/30/2014

EPA

United States Environmental Protection Agency
Washington, DC 20460

Completion Form For Injection Wells

Administrative Information

1. Permittee
Wexford Water Technologies, LLC

Address (Permanent Mailing Address) (Street, City, and ZIP Code)
PO Box 1030
3947 US 131 North
Kalkaska, MI 49646

2. Operator
Wexford Water Technologies, LLC

Address (Street, City, State and ZIP Code)
PO Box 1030
3947 US 131 North
Kalkaska, MI 49646

3. Facility Name	Telephone Number
Wexford Water Technologies Well No. 1	231-258-7300

Address (Street, City, State and ZIP Code)
990 N. US Highway 131
Manton, MI 49663

4. Surface Location Description of Injection Well(s)

State	County
Michigan	Wexford

Surface Location Description

NE 1/4 of SW 1/4 of SW 1/4 of NW 1/4 of Section 34 Township 23N Range 9W

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface
Location 2439 ft. frm (N/S) N Line of quarter section
and 77 ft. from (E/W) W Line of quarter section.

Well Activity	Well Status	Type of Permit
X Class I	___ Operating	X Individual
___ Class II	___ Modification/Conversion	___ Area : Number of Wells ___
___ Brine Disposal	X Proposed	
___ Enhanced Recovery		
___ Hydrocarbon Storage		
___ Class III		
___ Other		
Lease Number ______	Well Number WWT No. 1	

Submit with this Completion Form the attachments listed in Attachments for Completion Form.

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment (Ref. 40 CFR 144.32)

Name and Official Title (Please type or print)	Signature	Date Signed
Edward G. Ascione, President	[signature]	3/29/17

EPA Form 7520-9 (Rev. 12-11)

2.N CHANGES IN INJECTED FLUID

For Class III wells (Not Applicable to this Application)

2.O PLANS FOR WELL FAILURES

Outline contingency plans (proposed plans, if any, for Class II) to cope with all shut-ins or well failures, so as to prevent migration of fluids into any USDW.

Response:

The following summarizes the plan to address failure of the well to protect the surface environment and prevent migration of injected fluids into any USDW:

Wexford Water Technologies, LLC
Well No. 1 Contingency Plan

Monitoring and periodic routine investigative procedures will be performed on the injection well as required by applicable laws, permits and regulations, but not less frequently than once every five years as discussed in Section 2.P of this document. Pertinent data will be forwarded to the agencies as required. This monitoring and testing is required to ensure well integrity and safe operations.

1. If the well fails required monitoring or periodic testing standards, the well will be shut-in and the agency notified according to applicable regulations and permit conditions. After investigation into the cause for the failure, work plans will be prepared and reviewed with the regulators for repairing the problem.
2. If a workover is performed on the well, copies of all work reports and logs will be forwarded to the regulatory agencies within 45 days.
3. During the period of time required for a well workover or for shut-ins due to MIT failure, the contingency plans of the facility will include the following:
   a. If shut-in period is sufficiently brief, the waste generated during this period of time will be held in storage at the facility.
   b. If well shut-in is required for a longer period of time, some of the disposal may be shifted to another facility.
   c. If required, wastes will be removed from the facility via licensed waste transport vehicles and managed according to applicable regulations.

2.P MONITORING PROGRAM

Discuss the planned monitoring program. This should be thorough, including maps showing the number and location of monitoring wells as appropriate and discussion of monitoring devices, sampling frequency, and parameters measured. If a manifold monitoring program is utilized, pursuant to §146.23(b)(5), describe the program and compare it to individual well monitoring.

Response:

The monitoring program proposed for injection operations at this site will focus on the active injection well itself; no monitoring program specifically focused on the investigation of injectate containment via dedicated monitor wells is in place, nor is one proposed. Specifically, monitoring addressed under separate regulatory programs and purview is not addressed. The suitability of the well construction, operation requirements and the site geology for injection as demonstrated in previous sections of this permit application, indicate no monitoring related to future injection well operations is required. However, numerous data will be collected to monitor the injection well operation. This monitoring will take place using both continuous and periodic monitoring techniques.

MECHANICAL INTEGRITY AND PERIODIC TESTING

Periodic monitoring will be performed to conform with both Part I and Part II mechanical integrity requirements. Annual testing, including reservoir monitoring and annulus pressure testing, will be performed once per calendar year. In addition, once every fifth calendar year testing will be conducted that will include one of the following logs: temperature, noise, radioactive tracer, or oxygen activation logging per applicable non-hazardous well regulations. Casing inspection logs may be conducted to investigate corrosion if it is determined to be necessary when tubing is already removed from the borehole during a workover or stimulation.

Annual Part I mechanical integrity testing for Well No. 1 will include reservoir monitoring as specified in 40 CFR 146.13 (d) in addition to static or dynamic annulus pressure testing. Although test procedures or methods may be changed based on approval by Region 5 US EPA staff, the following procedure will be used for the first such monitoring to be performed. WWT will provide the agency with a minimum of 30 days notice of annual testing (when practical) to allow the agency to witness testing. Such notice is to include proposed procedures for testing.

Proposed procedures (or a suitable equivalent) are as follows:

1. Conduct Wellsite Safety Meeting

   A. Prior to commencement of field activities, conduct safety meeting with contractors and personnel to be involved with field services and MIT testing. Ensure that all safety procedures are understood and review days work activities.

2. Conduct Reservoir (Fall-Off or Static) Pressure Test

   A. For fall-off, record data regarding test well injection at typical operating conditions (constant rate). Rate, temperature and fluid consistency will be recorded during the injection period. Cumulative volume injected should also be recorded. Continue injection for a minimum of approximately five hours. Note that significant rate variations may yield poor quality data or require more complicated analysis techniques.

   B. Rig-up pressure gauge and run in well to a depth likely not to exceed approximately 3,225 feet or other depth approved by USEPA.

   C. For fall-off, obtain final stabilized injection pressure for a minimum of one hour. For static test, collect minimum of two pressure/temperature readings at depth. Ensure that the gauge temperature readings have also stabilized.

   D. After gauge recordings are stable, cease injection and monitor pressure fall-off. Continue monitoring pressure for a minimum of five hours or until a valid observation of fall-off curve is observed. For static gradient survey, the well will be shut-in for a minimum of 48 hours before testing. Wellbore pressure gradients will be obtained to establish fluid gradient and bottomhole pressure data will be collected for a minimum of 4 hours for static testing.

   E. Stop test data acquisition, rig-down and release equipment.

3. Annulus Pressure Test

   A. Stabilize well pressure and temperature.

   B. As practical, arrangements will be made for a representative from the US EPA to be present to witness this testing.

   C. Install ball valve or similar type "bleed" valve on annulus gate valve. Pressurize annulus to a minimum of 100 psig above maximum permitted injection pressure and shut-in valve. Install certified gauge on "bleed" type valve. The annulus may need to be pressurized and bled off several times to ensure an absence of air.

   D. Monitor and record pressure for 1 hour. Pressure may not fluctuate more than 3% during the one hour test.

   E. Lower the annulus pressure to normal operating pressure at end of test.

Part II (5 year) mechanical integrity demonstration for the well will be accomplished via one approved logging method such as temperature, noise, radioactive tracer or oxygen activation logging. Part II testing will be performed upon completion of the well, and every five years thereafter. WWT will provide the agency with a minimum of 30 days notice of Part II testing to allow the agency to witness data collection activities. Although WWT may utilize any acceptable method per EPA procedure approval, at this time it is proposed that temperature logging be utilized for future Part II mechanical integrity testing as follows:

1. Conduct Differential Temperature Log

   A. Shut-in well for stabilization (minimum of 24 hours) prior to running base temperature log.

   B. Rig-up temperature log and run base log from surface to total depth. Pull tool to surface and shut-in master valve.

   C. Rig down equipment and return the well to normal operations.

CONTINUOUS AND OPERATIONAL MONITORING

The well will have long string protective casing extending into the injection interval with cement circulated to the surface. The annulus area between the protective casing and injection tubing will be filled with fresh water inhibited with Corban or suitable equivalent. The annulus pressure will be continually monitored to detect any leaks in the tubing or casing and maintained at a pressure of more than 100 psi above the tubing pressure. Details regarding the system components are provided in Sections 2.L and 2.M of this document.

Monitoring of physical parameters associated with injection operations will be conducted pursuant to 40.CFR.146 regulations. At a minimum the monitoring will include injection pressure, annulus pressure, injection rate, injection volume, annulus level and injectate characteristics. Details regarding this monitoring follows. Automatic shut-down equipment will be operated to ensure that maximum pressure or minimum annulus differential requirements are not exceeded.

An electronic data recorder will be used to document annulus and injection pressure, along with flow rate at not less than 1-minute intervals. A recorder will also be used to track injection flow rate. Pressure transducers located in appropriate taps near the wellhead will be used to measure pressures. Flow rate will be measured utilizing an appropriate turbine meter and totalizer or suitable equivalent. Well operators will visually inspect the recorders on a daily basis when injection takes place to ensure proper operation.

The annulus tank will have sufficient reservoir capacity to accommodate the anticipated volume fluctuations due to temperature and pressure limitations. The annulus will be equipped with a full length armored reflex sight glass or electronic level indicator capability, pressure relief valve and independent liquid fill nozzle. The annulus tank level and annulus oil added will be visually inspected and recorded daily by the well operators when the well is used for injection. If any annulus fluid is added or removed, it will be recorded by the well operators on an operator log sheet.

Waste Characterization and Analysis

Injectate characteristics are to be monitored by collecting samples per the approved Waste Analysis Plan. One sample will be collected on a quarterly basis from the injection flow line or tank. The waste analysis is designed to provide representative data regarding average injectate chemical constituents. Information regarding the quarterly and annual sampling is presented in Tables P-1 and P-2. Additional information regarding proposed waste analysis is presented in the Waste Analysis Plan included at the end of Section 2.P of this document.

Table P-1
Wexford County Landfill Quarterly Analytical Reporting

Ignitability (flash point)	Temperature	1,4-Dichlorobenzene	Sodium
Alkalinity	Wellhead TDS	1,2-Dichloroethane	Chloride
Reactive Sulfide	Wellhead TOC	Dichloroethylene	Nitrate+Nitrite
Cyanide	Benzene	Tetrachloroethylene	Total Inorganic Nitrogen
pH	Carbon Tetrachloride	1,1 Trichloroethylene	Ammonia
Eh	Chlorobenzene	Vinyl Chloride	
Specific Gravity	Chloroform	Potassium	

Table P-2
Wexford County Landfill Annual Analytical Reporting

Arsenic
Barium
Lead

UIC WASTE ANALYSIS PLAN
Class I Deepwell

for
Wexford Water Technologies, LLC

Class I Deepwell WDW No. 1;
EPA Permit # TBD
MDEQ Permit # TBD

Wexford County Michigan

August 5, 2015
Revised June 2017

Prepared By:
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Phone: (303) 290-9414
Fax: (303) 290-9580

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1.0 INTRODUCTION

1.A Background

The purpose of this Waste Analysis Plan (WAP) is to characterize the non-hazardous landfill leachate waste water to be injected into the Wexford Water Technologies (WWT) Well No. 1 located at the Wexford County Landfill in Wexford County Michigan. WWT will be responsible for implementing this WAP. UIC Well No. 1 will be constructed in 2015 or 2016. Waste will be injected into the Traverse and/or Dundee Formation at a maximum depth of approximately 4,000 feet. Alternatively, if neither the Traverse nor Dundee are ideal injection zones, the well may completed to a total depth of up to 6,000 feet with injection into the Detroit River, Amherstburg, Sylvania, Bois Blanc and/or Bass Islands.

WWT intends to operate the well consistent with Title 40 of the Code of Federal Regulations (40 CFR), Section 146.13 that requires operators of Class I underground injection wells to monitor and analyze the fluids injected into the well "to yield representative data of their characteristics." This waste analysis plan also fulfills the specifications at 40 CFR 146.68 by presenting parameters for which the waste will be analyzed, methods that will be used to test for these parameters, and methods that will be used to obtain representative samples of the waste to be analyzed.

1.B Sources

The Wexford County Landfill generates non-hazardous leachate that originated from the Wexford County Subtitle D sanitary landfill. There is no SIC code for sanitary landfill leachate.

The waste waters produced at the landfill include water collected from both the primary and secondary leachate collection systems; wastewater in both systems originates from leachate generated by water infiltration through sanitary landfill waste. Some groundwater or run-off may also be added to this leachate if necessary. Fluids generated during well maintenance or testing activities may also be reinjected into the well. The waste stream is primarily composed of inorganic, non-hazardous compounds such as chloride, and potassium, with a TDS of approximately 7,000 ppm.

Waste water is first accumulated in each landfill cell, then piped to a single leachate collection tank. Although some settling may occur and WWT may elect to filter waste water prior to injection in the future, no waste treatment is performed in the tank.

1.C Summary

The major components of the WWT waste characterization and UIC monitoring program include:

- Volume Monitoring
- Sampling and Analysis
- Quality Assurance/Quality Control

These components are addressed in Sections 2 and 3, below.

The WAP may be reviewed and, if necessary, revised if new waste constituents or conditions are identified that may significantly alter the physical properties of the waste. Revisions to the WAP may also be required if new permit conditions are added by the Agency for cause. Any future revisions to the WAP, upon approval, will become part of the administrative record and constitute a minor modification of the permit. Compatibility issues regarding the subsurface rock matrix and well construction materials are documented in the permit application and are not addressed in this WAP.

2.0 PROCEDURES

2.A Volume Monitoring

As discussed in the text of the 2015 Permit Application, flow and pressure recorders are to be used to continuously monitor injection pressure, annulus pressure, and flow rate; totalized cumulative volumes for the well will be calculated from monitoring data. A summary of recorded data will be provided to the US EPA and MDEQ per applicable permit requirements. The remaining portions of this WAP address physical and chemical characterization of the waste.

2.B Waste Characterization

Waste analysis parameters were selected based on process knowledge, historical analysis, and analysis suggested by EPA Region 5 guidance. These parameters include pH, TDS, TSS, and applicable organic toxicity characteristics. The pH is generally neutral (6.5 to 7.5). The total dissolved solids (TDS) concentration of the waste is also a useful indicator of fluid properties. Calcium, potassium and sodium are the predominant cations and chloride is the predominant anion. Because the native brine present in any of the proposed injection formations contain high TDS including high cation-anion concentration, injectate will have a lower TDS concentration that natural formation waters.

Daily testing for pH, Eh, specific conductance and temperature will be performed on days that waste is injected; alternatively, WWT may substitute daily testing for continuous in-line monitoring. Although only a limited number of chemical constituents are expected in injectate, a relatively comprehensive analysis will be performed on a quarterly basis. The leachate originates from a sanitary landfill, but a more comprehensive analysis will ensure the non-hazardous nature of injectate. However, analysis excludes compounds like pesticides or herbicides because historical process knowledge indicates that the wastewaters are not expected to contain measurable quantities of these compounds. Wastewater is not expected to be ignitable, reactive, or corrosive, but waste will be analyzed for flashpoint, reactive cyanide, and pH on a quarterly basis as a basic way to monitor the non-hazardous nature of the waste and to ensure any trends or changes are identified.

Table 2-1 of the following section lists the parameters and monitoring frequency used to characterize wastewater to be injected into the WWT Well No. 1. The table also summarizes the applicable analytical method and reporting units for each. Characterization parameters were selected based on historical leachate sampling and identified for characterization needed to satisfy regulatory requirements and applicable specifications listed in typical Region 5 non-hazardous UIC permits.

2.C Sampling and Analysis

Samples will be collected daily or quarterly via grab sample from the waste injection line or the waste storage tank during calendar days or quarters when injection of waste takes place. The waste analysis to be conducted is designed to acquire representative samples of typical injectate. WWT, Wexford County Landfill, LLC personnel, contractor personnel, or contracted analytical laboratory personnel will collect required on-site waste stream samples. Sampling procedures will be conducted at the direction of site representatives and in accordance with the certified or accredited analytical laboratory procedures, and will meet the minimum current standard US EPA procedures. The grab sample will be sent to an independent contract laboratory for analysis. Sufficient mixing and residence time in the system will have occurred at this sampling point for the waste to be representative of the waste stream that is being injected. The sampler's name, sampling point, and date sampled will be documented using COC methods specified in Section 3.A..

Table 2-1 presents the parameters, analytical methods, reporting unit and sample frequency for each test parameter. Sampling and analytical methods will meet or exceed the standards cited below or as presented in USEPA "Methods for the Chemical Analysis of Water and Wastes" or "Standard Methods for the Examination of Water and Wastewater".

TABLE 2-1
WWT
CLASS I WASTE SAMPLING AND ANALYSIS SUMMARY

Test Parameter	Example Test Methods*	Reporting Units	Frequency
Ignitability (flash point)	SW846 1010, SW1010A	---	Quarterly
Alkalinity	SM2320-BICARB SM2320-TOTAL	Mg/L	Quarterly
Reactive Sulfide and Cyanide	SW846 7.3.3.2/ 7.3.4.1/ 7.3.4.2	---	Quarterly
pH	USEPA 150.1	pH units	Daily or Continuous
Eh	Measurement using oxidation-reduction potential instrumentation	Mvolts	Daily or Continuous
Specific Gravity	Hydrometer, ASTM 2710F, D5057		Daily or Continuous
Temperature	Thermometer	°F	Quarterly
Wellhead TDS	USEPA 160.1	mg/L	Quarterly
Wellhead TOC	USEPA 160.2	mg/L	Quarterly

Test Parameter	Example Test Methods*	Reporting Units	Frequency
Select Characteristic Constituents			
Benzene (D018)	USEPA 8260B/624	mg/L	Quarterly
Carbon Tetrachloride (D019),	USEPA 8260B/8021B	mg/L	Quarterly
Chlorobenzene (D021),	USEPA 8260B/8021B	mg/L	Quarterly
Chloroform (D022),	USEPA 8260B/8021B	mg/L	Quarterly
1,4-Dichlorobenzene (D027),	USEPA 8260B/8021B	mg/L	Quarterly
1,2-Dichloroethane (D028),	USEPA 8260B/8021B	mg/L	Quarterly
Dichloroethylene (D029),	USEPA 8260B/8021B	mg/L	Quarterly
Tetrachloroethylene (D039),	USEPA 8260B/8021B	mg/L	Quarterly
1,1 Trichloroethylene (D040)	USEPA 8260B/8021B	mg/L	Quarterly
Vinyl Chloride (D043)	USEPA 8260B/8021B	mg/L	Quarterly
Additional Parameters			
Potassium	USEPA 200.8/6020A	mg/L	Quarterly
Sodium	USEPA 200.8/6010B, 6020A, 3005A	mg/L	Quarterly
Chloride	USEPA 325.2/A4500	mg/L	Quarterly
Nitrate+nitrite	USEPA 200.8/6500	mg/L	Quarterly
Total inorganic nitrogen	USEPA 350.2	mg/L	Quarterly
Ammonia	USEPA 350.2	mg/L	Quarterly
Arsenic (D004)	USEPA 6000 series	mg/L (ppm)	Quarterly
Barium (D005)	USEPA 6000 series	mg/L (ppm)	Quarterly
Cadmium (D006)	USEPA 6000 series	mg/L (ppm)	Quarterly
Chromium (D007)	USEPA 6000 series	mg/L (ppm)	Quarterly
Lead (D008)	USEPA 6000 series	mg/L (ppm)	Quarterly
Additional Parameters			
Mercury (D009)	USEPA 6000 Series	mg/L (ppm)	Quarterly
Selenium (D010)	USEPA 6000 Series	mg/L (ppm)	Quarterly
Silver (D011)	USEPA 6000 Series	mg/L (ppm)	Quarterly
Endrin (D012)	USEPA 8081A/8085/8270	mg/L (ppm)	Quarterly
Lindane (D013)	USEPA 8081A/8270	mg/L (ppm)	Quarterly
Methoxychlor (D014)	USEPA 8270D/8081A	mg/L (ppm)	Quarterly
Toxaphene (D015)	USEPA 8081A/8270	mg/L (ppm)	Quarterly
2,4-D (D016)	USEPA 8151A	mg/L (ppm)	Quarterly

Test Parameter	Example Test Methods*	Reporting Units	Frequency
2,4,5-TP (Silvex) (D017)	USEPA 8151A/8321/8085	mg/L (ppm)	Quarterly
Chlordane (D020)	USEPA 8081A/8270	mg/L (ppm)	Quarterly
o-Cresol (D023)	USEPA 8270C	mg/L (ppm)	Quarterly
m-cresol (D024)	USPEA 8270C	mg/L (ppm)	Quarterly
p-Cresol (D025)	USEPA 8270C	mg/L (ppm)	Quarterly
Cresol (D026)	USEPA 8270C	mg/L (ppm)	Quarterly
2,4-Dinitrotoluene (D030)	USEPA 8270C	mg/L (ppm)	Quarterly
Heptachlor (and its epoxide) (D031)	USEPA 8081A/8085/8270	mg/L (ppm)	Quarterly
Hexachlorobenzene (D032)	USEPA 8081A/8085/8270	mg/L (ppm)	Quarterly
Hexachlorobutadiene (D033)	USEPA 821B/8260B	mg/L (ppm)	Quarterly
Hexachloroethane (D034)	USEPA 8270C/D	mg/L (ppm)	Quarterly
Methyl ethyl ketone (D035)	USEPA 8260B/8261	mg/L (ppm)	Quarterly
Nitrobenzene (D036)	USEPA 8270D	mg/L (ppm)	Quarterly
Pentachlorophenol (D037)	USEPA 8270D	mg/L (ppm)	Quarterly
Pyridine (D038)	USEPA 8270D	mg/L (ppm)	Quarterly
2,4,5-Trichlorophenol (D041)	USEPA 8270D	mg/L (ppm)	Quarterly
2,4,6-Trichlorophenol (D042)	USEPA 8270D	mg/L (ppm)	Quarterly
Vinyl chloride (D043)	USEPA 8021B/8260B	mg/L (ppm)	Quarterly

Notes: * Test methods cited are examples; alternative methods with equal or better detection limits may be used

The parameter list included in this WAP was developed based on process knowledge and results of ongoing quarterly and annual analysis of leachate in the leachate collection tank as required by the Hydrogeologic Monitoring Plan (2008) for the facility incorporated by reference in the Solid Waste Disposal Area Operating License. Quarterly and annual analysis of leachate in the Leachate Collection Tank is performed, as required by the Landfill Operating License.

Results of prior annual and quarterly analyses collected to satisfy Landfill Operating License are presented in appendices to Section H of the EPA UIC Permit Application, which also includes a summary of analytical results by quarter. As shown in this appendix, analysis shows that only a relatively few organic and inorganic constituents are detected, and inorganic parameters are analyzed on an annual basis as required by the Landfill Operating License. In addition, the waste will be sampled and analyzed for other parameters required by this WAP as shown in Table 2-1, including but not limited to pH, Eh, specific gravity, temperature, TDS and TOC, along with chloride and potassium that make up a major portion of the waste stream. Therefore, based on process knowledge and historical analytical results, the WAP parameter list provides analysis for 1) EPA recommended parameters; 2) TC compounds to ensure non-hazardous compliance, and 3) compounds typically present in injectate at significant concentrations (e.g. chloride).

It is important to note that WWT is a subsidiary of the landfill operator, Wexford County Landfill, LLC, which is required to perform ongoing leachate analysis as part of MDEQ landfill operating permits and requirements. Wexford County Landfill, LLC may collect and analyze samples of injectate as described in this WAP, and share resulting data with WWT. That is, sample analysis obtained under the Landfill Operating License program may be used and augmented as necessary to comply with the UIC program requirements, thus allowing Wexford County Landfill, LLC to collect samples for the landfill operating permit and UIC programs in one sampling event, when practical, accomplishing compliance in a more cost effective manner.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

3.A General Sampling and Analytical Information

Sampling protocols outlined in this document are to be followed. WWT is responsible for obtaining data necessary to comply with this WAP, and will ensure adherence to guidelines set forth in the referenced standards listed in Section 2.C or equivalents, as appropriate. Approved sample collection vessels and preservation techniques from 40 CFR 136.3 or equivalent will be followed as applicable and appropriate. These will include preservation in plastic or glass sample containers provided by the laboratory and storage in a sample refrigerator or cooler for shipment to the laboratory. WWT reserves the option to choose alternate laboratories for testing provided equivalent QA/QC standards are met.

COC Form Content

Each sample taken will be accompanied by facility or contract laboratory Chain of Custody (COC) form that provides a record of sample handling starting with sample acquisition, documenting the process up to laboratory analysis. Samples taken are to be logged in the field using the COC, sealed, and delivered to the laboratory with a COC form. The COC form shall provide the following items collected by the sampler:

1. Sample ID including code or name, in addition to date and time;
2. Name of sample collector; (include sampling company name if not site personnel);
3. Sample collection method;
4. Sample collection date;
5. Sample collection point; and
6. Sample presentation technique, as applicable

Sample container label will also include a COC seal. Sample chain-of-custody will be followed at all times during the sampling and subsequent analysis. Chain-of-custody will be used to document the handling and control necessary to identify and trace a sample from collection through to final analytical results. Standard laboratory COC forms that document the times and dates of all personnel handling the sample, along with standard labels and container seals sufficient to distinguish between samples and prevent tampering, will be acceptable.

Reporting and Records Retention

Analytical reports and regulatory submittals regarding the nature and composition of injected fluids are to be maintained in the well files until authorization is obtained from US EPA, in writing, to discard the records. All laboratory reports submitted to US EPA will include, at a minimum, the following:

1. Test description;
2. Analytical method for parameter detection;
3. Identification of analysis date and analyst;
4. Result and units; and
5. Analytical reporting limits.

The following sections present QA/QC parameters which will be followed to help to assure the adequacy of the sampling and analytical techniques for wellhead sampling and analysis described in this plan.

3.B Sampling Controls

1. Equipment Blanks

   Fluid samples will be obtained directly from the sample accumulation container before being sealed in the sample container shipped to the laboratory. In this case, no equipment cleaning blanks will be required. If samples cannot be directly placed in the bottles intended for preservation and shipment, equipment blanks will be taken as deemed appropriate by WWT.

2. Trip Blanks

   If the laboratory analysis is ever suspect because it contains anomalous parameters, trip blanks will be collected to assess in-transit contamination. The trip blank will consist of sample containers filled and sealed at the laboratory with laboratory-provided deionized (DI) water that accompany the sample containers used throughout the sampling event. The sample containers shall be handled in the same manner as the samples. The trip blank(s) will be sent to the laboratory for analysis of, at a minimum, the same parameters specified in the sampling plan above. A minimum of one (1) trip blank per sampling event will be utilized, when deemed necessary. At the discretion of WWT, trip blanks may be submitted with any sample to verify representativeness of the sampling program.

3. Sample Duplicates

   On advance written request of US EPA, duplicate samples will be taken to further assess the QA/QC program of the laboratory conducting the analysis. Such samples will be drawn from the same site from which primary samples will be taken consecutively from the same sampling tap or sample location to ensure representativeness. The duplicate will be labeled with a sample number that will not conflict with the other samples, but will not be discernable to the laboratory as a duplicate sample. Upon the request of US EPA or at the discretion of site representatives, one duplicate sample per selected sampling event will be taken and analyzed for the same parameters as the sampling event.

3.C Analytical Controls

1. Equipment Calibration

   The selected analytical laboratories must maintain QA/QC records of the frequency and type of instrument calibration performed at the laboratory and in the field. Any calibration of thermometers, gauges, chromatographs, spectrometers and other analytical equipment will be conducted according to appropriate instrument manufacturer specifications and manufacturer recommended frequencies or as dictated by applicable laboratory QA/QC plans that have been developed by the laboratory. Valid calibration certificates for instruments used offsite by a certified lab will be maintained at that facility. Calibration data for onsite field testing or continuous monitoring will be maintained as part of the site well records.

2. Data Reduction

   Transcription of the raw data into the reportable units is conducted by the laboratory in accordance with the selected laboratory Q/A plan. Data reduction utilized in the analysis and reporting process is presented in the reports to the US EPA for each sampling and analysis event. Data is recorded on hand written or computer work sheets that include identification data, sample data and all data required for calculations, or on computer print-outs accompanied by operator notes and summaries.

3. Data Verification

   Data verification is conducted after each sampling event by assigned laboratory personnel and includes, at a minimum, review of chain-of-custody forms, equipment calibration records and data completeness. Spot checks of raw data versus reported data are performed to review math accuracy, significant numbers and reporting units. In addition, certified laboratory standard quality assurance/quality control requirements or checklists are utilized to verify individual test methods such as blanks, standards, and for comparisons of internal lab test duplicate results. Problems with any of these items will be indicated in the analytical report presented to the agency.

4. Internal Quality Control

Per the laboratory QA/QC program, certified quality control samples from appropriate commercial sources or the US EPA, may be run periodically with sample batches. Internal quality control are addressed by disclosure of the laboratory's use of blanks, blind standards, matrix spikes and matrix spike duplicates, preparation of reagents, and laboratory duplicate or replicate analyses.

3.D Actions

1. Corrective Actions

Corrective actions are implemented by laboratories if the analytical or sampling methods do not achieve plan objectives or data verification identifies inconsistencies in the results. Actions may entail re-sampling the waste stream and/or re-analyzing the fluid for a particular parameter, re-calibrating an analytical device, or other appropriate actions as dictated by the specific situation encountered. Action levels are typically taken in accordance with any applicable standards from USEPA "Methods for the Chemical Analysis of Water and Wastes" or "Standard Methods for the Examination of Water and Wastewater". WWT representatives may, at their discretion, require re-sampling and retesting to confirm results that fall outside the historical range of expected analytical results, or outside equipment calibration curves.

2. Reports to US EPA Region 5

Reports of waste analysis to US EPA will contain a table summarizing the sampling date, units and analytical result for each of the parameters listed in table 2-1 of this document. Additionally, analytical results (i.e. data), including chain of custody forms, will be submitted to US EPA.

3.E Re-Characterization

WWT shall review the results of quarterly leachate analysis to ensure that injectate is sufficiently characterized. At the discretion of WWT or at the written request of EPA, re-characterization efforts may be conducted should a significant change occur in the injectate composition based on quarterly analyses, or if necessitated or required by process changes or new regulations.

The waste stream will be re-characterized as deemed necessary by WWT if analyses shows a significant change in parameter concentration, particularly toxicity characteristic compound composition that might affect the non-hazardous nature of the waste. In this instance, sampling may be performed more frequently to obtain more representative analysis of waste composition, to ensure that the overall composition of injectate is still non-hazardous. Any future revisions to the WAP, upon approval, will become part of the administrative record and constitute a minor modification of the permit upon submittal by WWT.

2.Q PLUGGING AND ABANDONMENT PLAN

Submit a plan for plugging and abandonment of the well Including (1) describe the type, number, and placement (including the elevation of the top and bottom) of plugs to be used; (2) describe the type, grade, and quantity of cement to be used; and (3) describe the method to be used to place plugs, including the method used to place the well in a state of static equilibrium prior to placement of the plugs. Also, for a Class III well that underlies or is in an exempted aquifer, demonstrate adequate protection of USDWs. Submit this information on EPA Form 7520-14, Plugging and Abandonment Plan.

Response:

The following completed EPA Form 7520-14, Plugging and Abandonment Plan, is submitted to satisfy this requirement. The plan for the well is also summarized in graphical form (Figure Q-1) in this response. Costs associated with the plugging and abandonment of the well per the following procedures is presented in the completed plugging forms and in Response 2.R of this document.

Plugging and Abandonment Procedure (Assuming Traverse/Dundee Completion)

1. Prepare well and location for plugging. Move in and rig up well servicing rig, pipe racks and 100 bbl tank.
2. Install a test gauge on the annulus to perform a static pressure test. Ensure that the annulus is fluid filled and that the well has been shut-in for a minimum of 24 hours. Pressurize annulus to approximately 500 psig and isolate from the annulus system. Monitor annular pressure for one hour. The test will be successful if the pressure change is less than 3 percent of the starting pressure.
3. Displace tubing with kill brine as needed to control wellhead pressure. Dismantle wellhead and install blow-out preventer. Displace annulus with kill brine as needed to control pressure. Brine compatibility with cement to be used should be verified.
4. Remove injection tubing and packer. If packer will not unseat, proceed with fishing operations as needed to remove packer from hole or obtain approval to set retainer above packer and pump cement through packer.
5. Make-up mechanical plug on workstring and trip in hole. Set cement retainer or plug at top of disposal zone just above historical packer setting depth (±3,175 if Traverse). Test cement retainer or plug to 500 psig.
6. Move in cement and cementing equipment.
7. Displace hole below retainer with Class "A" cement with up to 4% bentonite. Unsting from retainer and spot 50 additional sacks on top of plug. Cement

volume has been calculated based on the following volumes:

> 7" casing from 3175' to 4050' at 0.2213 ft^3/ft = 194 ft^3
> 50 additional sacks with a yield of 1.18 $ft^3/sack$ = 59 ft^3

Therefore, the total volume of this plug would be 253 ft^3 which is equivalent to 215 sx of Class A cement with a yield of 1.18 $ft^3/sack$. Note that since wellbore fill is expected to be at a depth of 3,950' to 4,050' BGL, this volume of cement may have to be squeezed into the openhole of the injection interval.

8. Spot successive, continuous balanced cement plugs in 500' intervals from top of the cement retainer to surface (6 intervals required). Cement to be API Class "A" with not more than 4% bentonite. If "neat" Class A cement is pumped it will have the following slurry properties:

   water ratio - 5.20 gallons per sack
   slurry weight - 15.60 pounds per gallon
   slurry volume - 1.18 cubic feet per sack

   An estimated 550 sacks or 645 cubic feet of slurry will be required above plug.
9. Cut off wellhead approximately 4 feet BGL and weld cap with permanent maker on casing.
10. Rig down and move out all equipment.

The steel plate should be inscribed with waste disposal well identification information and the date of plugging. Federal and State representatives will have been invited to witness the plugging and sign the plug and abandonment form.

Plugging and Abandonment Procedure (Assuming Amherstburg/Bass Islands Completion)

1. Prepare well and location for plugging. Move in and rig up well servicing rig, pipe racks and 100 bbl tank.
2. Install a test gauge on the annulus to perform a static pressure test. Ensure that the annulus is fluid filled and that the well has been shut-in for a minimum of 24 hours. Pressurize annulus to approximately 500 psig and isolate from the annulus system. Monitor annular pressure for one hour. The test will be successful if the pressure change is less than 3 percent of the starting pressure.
3. Displace tubing with kill brine as needed to control wellhead pressure. Dismantle wellhead and install blow-out preventer. Displace annulus with kill brine as needed to control pressure. Brine compatibility with cement to be used should be verified.
4. Remove injection tubing and packer. If packer will not unseat, proceed with

fishing operations as needed to remove packer from hole or obtain approval to set retainer above packer and pump cement through packer.

5. Make-up cement retainer on workstring and trip in hole. Set retainer just above 5" liner top (± 2,975). Test cement retainer or to 500 psig.
6. Move in cement and cementing equipment.
7. Displace hole below retainer with Class "A" cement with up to 4% bentonite. Unsting from retainer and spot 50 additional sacks on top of retainer. Cement volume has been calculated based on the following volumes:

   5" liner from 6,000' to 3,000 at 0.09972 ft^3/ft = 300 ft^3
   7" casing from 3,000' to 2,975' at 0.2210 ft^3/ft = 3 ft^3
   50 additional sacks with a yield of 1.18 $ft^3/sack$ = 59 ft^3

   Therefore, the total volume of this plug would be 362 ft^3 which is equivalent to 307 sx of Class A cement with a yield of 1.18 $ft^3/sack$. Note that since wellbore fill is expected to be at a depth of 5,900' to 6,000' BGS, this volume of cement may have to be squeezed into the openhole of the injection interval.
8. Spot successive, continuous balanced cement plugs in 500' intervals from top of the cement retainer to surface (6 intervals required). The cement is to be API Class "A" with not more than 4% bentonite. If "neat" Class A cement is pumped it will have the following slurry properties:

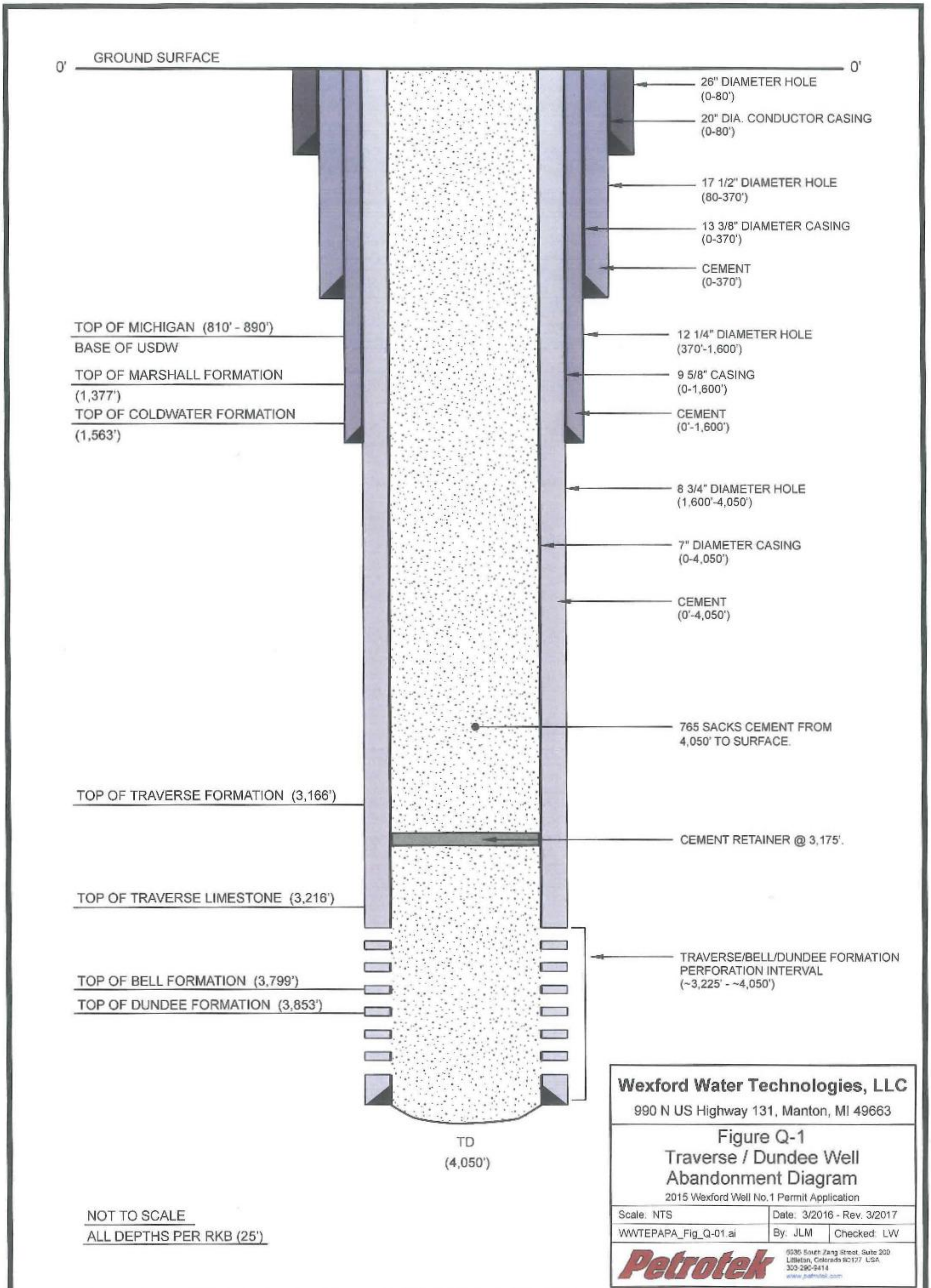
   water ratio - 5.20 gallons per sack
   slurry weight - 15.60 pounds per gallon
   slurry volume - 1.18 cubic feet per sack

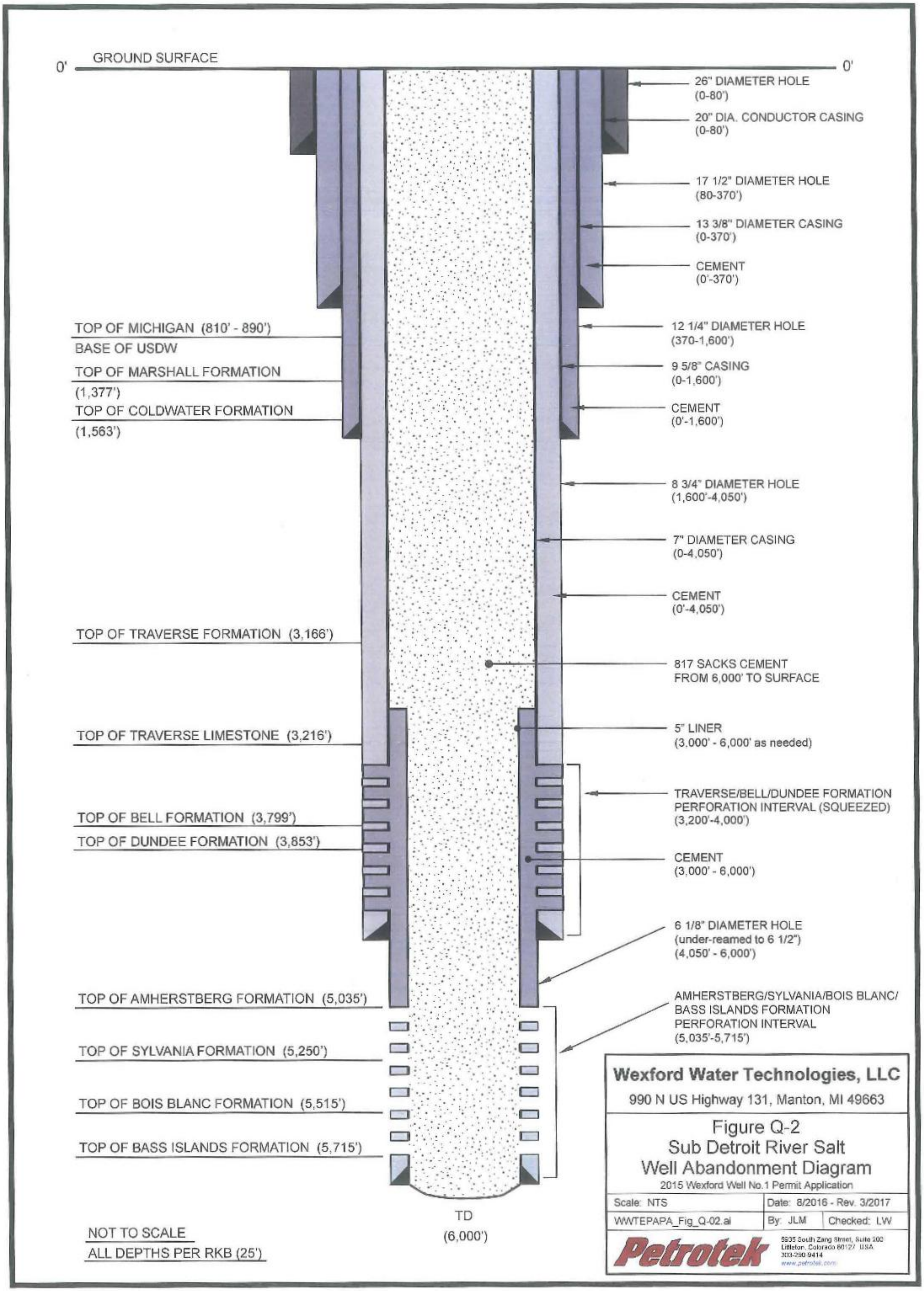
   An estimated 510 sacks or 598 cubic feet of slurry will be required above retainer.
9. Cut off wellhead approximately 4 feet BGS and weld cap with permanent maker on casing.
10. Rig down and move out all equipment.

The steel plate should be inscribed with waste disposal well identification information and the date of plugging. Federal and State representatives will have been invited to witness the plugging and sign the plug and abandonment form.

Post-Closure Care Requirements

WWT will provide notification of closure to USEPA, Region 5, the MDEQ and the local zoning authorities. Included with the notification will be information regarding the nature of the injected waste stream, identification of the depths of the injection and confining zones, well schematics and plugging records. WWT will retain, for a period of three years following the well closure, records reflecting the nature, composition and volume of all injected fluids. At the discretion of the director of USEPA, Region 5, WWT will then deliver the records to the director at the conclusion of the retention period, or dispose of such records upon written approval of the director.


0'
GROUND SURFACE
0'
26" DIAMETER HOLE
(0-80')
20" DIA. CONDUCTOR CASING
(0-80')
17 1/2" DIAMETER HOLE
(80-370')
13 3/8" DIAMETER CASING
(0-370')
CEMENT
(0-370')
TOP OF MICHIGAN (810' - 890')
BASE OF USDW
12 1/4" DIAMETER HOLE
(370'-1,600')
TOP OF MARSHALL FORMATION
(1,377')
9 5/8" CASING
(0-1,600')
TOP OF COLDWATER FORMATION
(1,563')
CEMENT
(0'-1,600')
8 3/4" DIAMETER HOLE
(1,600'-4,050')
7" DIAMETER CASING
(0-4,050')
CEMENT
(0'-4,050')
765 SACKS CEMENT FROM
4,050' TO SURFACE.
TOP OF TRAVERSE FORMATION (3,166')
CEMENT RETAINER @ 3,175'.
TOP OF TRAVERSE LIMESTONE (3,216')
TRAVERSE/BELL/DUNDEE FORMATION
PERFORATION INTERVAL
(~3,225' - ~4,050')
TOP OF BELL FORMATION (3,799')
TOP OF DUNDEE FORMATION (3,853')
TD
(4,050')
NOT TO SCALE
ALL DEPTHS PER RKB (25')
Wexford Water Technologies, LLC
990 N US Highway 131, Manton, MI 49663
Figure Q-1
Traverse / Dundee Well
Abandonment Diagram
2015 Wexford Well No.1 Permit Application
Scale: NTS
Date: 3/2016 - Rev. 3/2017
WWTEPAPA_Fig_Q-01.ai
By: JLM
Checked: LW
Petrotek
Littleton, Colorado 80127 USA
303-290-9414



0' GROUND SURFACE
0'
26" DIAMETER HOLE (0-80')
20" DIA. CONDUCTOR CASING (0-80')
17 1/2" DIAMETER HOLE (80-370')
13 3/8" DIAMETER CASING (0-370')
CEMENT (0'-370')
TOP OF MICHIGAN (810' - 890')
BASE OF USDW
TOP OF MARSHALL FORMATION (1,377')
TOP OF COLDWATER FORMATION (1,563')
12 1/4" DIAMETER HOLE (370-1,600')
9 5/8" CASING (0-1,600')
CEMENT (0'-1,600')
8 3/4" DIAMETER HOLE (1,600'-4,050')
7" DIAMETER CASING (0-4,050')
CEMENT (0'-4,050')
TOP OF TRAVERSE FORMATION (3,166')
817 SACKS CEMENT FROM 6,000' TO SURFACE
TOP OF TRAVERSE LIMESTONE (3,216')
5" LINER (3,000' - 6,000' as needed)
TRAVERSE/BELL/DUNDEE FORMATION PERFORATION INTERVAL (SQUEEZED) (3,200'-4,000')
TOP OF BELL FORMATION (3,799')
TOP OF DUNDEE FORMATION (3,853')
CEMENT (3,000' - 6,000')
6 1/8" DIAMETER HOLE (under-reamed to 6 1/2") (4,050' - 6,000')
TOP OF AMHERSTBERG FORMATION (5,035')
AMHERSTBERG/SYLVANIA/BOIS BLANC/ BASS ISLANDS FORMATION PERFORATION INTERVAL (5,035'-5,715')
TOP OF SYLVANIA FORMATION (5,250')
TOP OF BOIS BLANC FORMATION (5,515')
TOP OF BASS ISLANDS FORMATION (5,715')
TD (6,000')
NOT TO SCALE
ALL DEPTHS PER RKB (25')
Wexford Water Technologies, LLC
990 N US Highway 131, Manton, MI 49663
Figure Q-2
Sub Detroit River Salt
Well Abandonment Diagram
2015 Wexford Well No.1 Permit Application
Scale: NTS
Date: 8/2016 - Rev. 3/2017
WWTEPAPA_Fig_Q-02.ai
By: JLM
Checked: LW
Petrotek
5935 South Zang Street, Suite 200 Littleton, Colorado 80127 USA 303-290-9414
www.petrotek.com

OMB No. 2040-0042 Approval Expires 11/30/2014

EPA

United States Environmental Protection Agency
Washington, DC 20460

PLUGGING AND ABANDONMENT PLAN

Name and Address of Facility	Name and Address of Owner/Operator
Wexford Water Technologies, LLC 990 N. US Highway 131, Manton, MI 49663	Wexford Water Technologies, LLC PO Box 1030, 3947 US 131 North, Kalkaska, MI 49646

Locate Well and Outline Unit on Section Plat - 640 Acres

N
W X E
S

State	County	Permit Number
Michigan	Wexford	MI-165-1I-0002

Surface Location Description

NE 1/4 of SW 1/4 of SW 1/4 of NW 1/4 of Section 34 Township 23N Range 9W

Locate well in two directions from nearest lines of quarter section and drilling unit

Surface Location 2439 ft. frm (N/S) N Line of quarter section
and 77 ft. from (E/W) W Line of quarter section.

TYPE OF AUTHORIZATION

- [x] Individual Permit
- [ ] Area Permit
- [ ] Rule

Number of Wells 1

Lease Name

WELL ACTIVITY

- [x] CLASS I
- [ ] CLASS II
  - [ ] Brine Disposal
  - [ ] Enhanced Recovery
  - [ ] Hydrocarbon Storage
- [ ] CLASS III

Well Number WWT No. 1

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT (LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
9 5/8"	36	1,600	1,600	12 1/4
7"	23	4,050	4,050	8 3/4
5"	18 LINER	4,000-6,000	4,000-6,000	6 1/8

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- [x] The Balance Method
- [ ] The Dump Bailer Method
- [ ] The Two-Plug Method
- [ ] Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (Inche:	5	7					
Depth to Bottom of Tubing or Drill Pipe (ft	6,000	4,050					
Sacks of Cement To Be Used (each plug)	817	765					
Slurry Volume To Be Pumped (cu. ft.)	965	903					
Calculated Top of Plug (ft.)	0	0					
Measured Top of Plug (if tagged ft.)	0	0					
Slurry Wt. (Lb./Gal.)	15.6	15.6					
Type Cement or Other Material (Class III)	A	A					

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (if any)

From	To	From	To

Estimated Cost to Plug Wells

Estimated cost of workover rig, cement and equipment to plug well is $30,460 for a shallow well and $32,265 for a deep well. Plug 1 only required if deep injection interval drilled.

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

Name and Official Title (Please type or print)	Signature	Date Signed
Edward G. Ascione, President		3/29/17

EPA Form 7520-14 (Rev. 12-11)

2.R NECESSARY RESOURCES

Submit evidence such as a surety bond or financial statement to verify that the resources necessary to close, plug or abandon the well are available.

Response:

Included as documentation for this Attachment are copies of a closure cost estimate for the WWT Well No. 1 and the bond issued in favor of the Michigan Department of Environmental Quality, Director of Mineral Wells to demonstrate financial assurance per applicable regulations. Wexford Water Technologies, LLC requests that the state financial assurance mechanism also be accepted by US EPA to satisfy federal financial assurance requirements.

Updated materials, as may become necessary, will to be forwarded to MDEQ and to the US EPA regarding financial assurance by Wexford Water Technologies, LLC to the following address:

US Environmental Protection Agency
Region 5 UIC Branch
DI Section
77 West Jackson Blvd.
Chicago, IL 60604-3590

With respect to continued demonstration of financial assurance, the Bond arrangement will be maintained as required by applicable regulations. Within ninety (90) days after the close of each fiscal year, the permittee will obtain verification that the amount used for financial assurance is sufficient to address updated plugging and abandonment costs and will submit updated financial assurance information to the US EPA if the cost of plugging and abandonment has exceeded the existing financial assurance or if the financial assurance mechanism is altered. Costs will be updated for inflation annually based on the most recently available US Bureau of Labor Statistics data from the Producer Price Index for support activities for oil and gas operations (PCU213112213112) or suitable equivalent such as obtaining quotations for required services. In the event that costs exceed existing financial assurance, the information submitted to the Director will consist of a letter from the permittee regarding the change in the financial assurance requirements, verification from the appropriate financial institution regarding the increased financial assurance and a copy of the independent geologist or engineering estimate of the updated plugging and abandonment costs.

Petrotek

Petrotek Engineering Corporation 5935 South Zang Street, Suite 200 Littleton, Colorado 80127 USA (303) 290-9414 FAX (303) 290-9680

August 12, 2016

Mr. Eddie Ascione
President
Wexford Water Technologies, LLC
PO Box 1030
3947 US 131 North
Kalkaska, Michigan 49646

RE: Updated 2016 Plugging and Abandonment Cost Estimate for Class I Well (Primary Shallow or Deep Secondary Targets) Wexford Water Technologies, LLC (WWT) Disposal Well No. 1 Manton, Michigan

Dear Mr. Ascione:

As requested, Petrotek has completed revised plans for drilling and completing the proposed WWT No. 1 well at the Manton location in Wexford County based on MDEQ comments and input. We have also prepared plugging and abandonment procedures for the well and a cost estimate for the associated costs for the closure of the well. This well is proposed as a Traverse/Dundee injector with a total depth of up to 4,050 feet in the primary target zones. The well may be deepened to approximately 6,000 feet if additional disposal capacity is required once testing data is evaluated. It is located in close proximity to oilfield contractor service companies in the northern Michigan Basin.

A copy of EPA Form 7520-14 is provided in the permit application (Section 2.Q) that summarizes the plugging plan. Copies of Form EQP 7200-14 are included in the MDEQ application for both the shallow and deep completion options. The State of Michigan financial assurance amount maintained for this well is $33,000 and this amount is sufficient based on satisfying minimum requirements for plugging that do not include budget for any additional integrity testing or the decommissioning of any related surface facilities. As of July 31, 2016 the line item budgeting is as follows:

Shallow Casing	Deep Casing	Cost Item
$ 16,660	$ 19,465	Cement
$ 5,000	$ 5,000	Rig or Pulling Unit with Rental Equipment
$ 500	$ 500	Welder
$ 3,300	$ 2,300	7" Csg Shallow Well or 5" Csg Deep Well Cement Retainer
$ 5,000	$ 5,000	Miscellaneous
$ 30,460	$ 32,265	Total

The plugging cost estimate for the proposed well is currently estimated not to exceed $32,265.

As always, if you have any questions or require further information regarding any issues related to the wells, feel free to contact any of us at Petrotek.

Sincerely,

Petrotek Engineering Corporation
Ken Cooper, PE

Wexford Water Technologies, LLC
P.O. Box 1030
3947 U.S. 131 North
Kalkaska, MI 49646

Underground Injection Control Branch
U.S. Environmental Protection Agency
77 West Jackson Boulevard, WU-16J
Chicago, Illinois 60604-3590

To Whom It May Concern:

This letter requests that the attached State Bond #1121979 in the amount of Thirty-three thousand dollars ($33,000) be considered an acceptable mechanism for meeting the Federal Underground Injection Control program financial responsibility requirement for the following well:

1. Well Name Well No. 1
2. Well Location: Township 23N Range 9W
   Section 34 1/4 Section NW
   County Wexford
3. UIC Application # TBD
4. Owner/Operator Name Wexford Water Technologies, LLC
5. Address P.O. Box 1030, 3947 US 131 North
   Kalkaska, MI 49646
6. Phone (231) 258-7300

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

Edward G. Ascione, President	[signature]	8/5/2015
Name and Official Title	Signature	Date Signed

cc: Mark Snow, Michigan Department of Environmental Quality

2.S AQUIFER EXEMPTIONS

If an aquifer exemption is requested, submit data necessary to demonstrate that the aquifer meets the following criteria: (1) does not serve as a source of drinking water; (2) cannot now and will not In the future serve as a source of drinking water; and (3) the TDS content of the ground water is more than 3,000 and less than 10,000 mg/l and is not reasonably expected to supply a public water system. Data to demonstrate that the aquifer is expected to be mineral or hydrocarbon producing, such as general description of the mining zone, analysis of the amenability of the mining zone to the proposed method, and time table for proposed development must also be included. For additional information on aquifer exemptions, see 40 CFR 144.7 and 146.04.

Response:

No aquifer exemption is requested for the injection interval or injection zone at this site which will likely consists of portions of the Traverse Limestone, and/or the Dundee Limestone Formation. The injection zone is separated from the lowermost USDW by a number of low permeability shales, with an average thickness of over 1,400 feet below the facility. Zones within the Traverse and Dundee will exhibit water quality greatly in excess of 10,000 ppm and probably over 100,000 ppm TDS. Also, secondary injection zone target units below the Dundee (Detroit River through Bass Islands) are expected to exhibit TDS greatly in excess of 10,000 ppm, should these zones be sought as injection targets if the Traverse and/or Dundee prove to be unacceptable for sufficient injection rates.

2.T EXISTING EPA PERMITS

List program and permit number of any existing EPA permits, for example. NPDES, PSD, RCRA, etc.

Response:

No federal permits other than the USEPA UIC permit requested by submittal of this document (number MI-165-1I-0002 TBD) apply to the proposed WWT well or to the Wexford County Landfill operation.

2.U DESCRIPTION OF BUSINESS

Give a brief description of the nature of the business.

Response:

The Wexford County Landfill is a solid waste disposal landfill serving local residential customers that is owned by Wexford County Landfill, LLC, a privately owned Michigan corporation. Wexford Water Technologies, LLC, is a subsidiary of Wexford County Landfill, LLC, that has been organized to drill and operate a Class I well at the Wexford County Landfill to manage leachate and fluids generated by the environmentally responsible operation of the landfill. Until 2011, the landfill was owned and operated by the county government at which time it was sold to Wexford County Landfill, LLC.